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Surveillance Report on SAVY 4000 and Hagan Nuclear Material Storage Containers Update for Fiscal Year 2020

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Executive Summary

A Surveillance Program is in place to assess how nuclear material storage containers at LANL are aging in-service. This program is guided by the LANL Surveillance Plan [1] which is required by DOE M441.1-1. The plan is modified as necessary to ensure that any issues identified during surveillance or laboratory studies are examined in future surveillances, and that any lifetime implications are taken into account. Under the plan, overall container integrity is evaluated by a combination of visual inspections and photographs. Multiple measurements are made to assess the SAVY 4000 performance, including, helium leakage rate, O-ring hardness (durometer), O-ring compression set, filter performance and filter water resistance. The containers for surveillance are chosen annually based on the previous surveillance program results and observations. The surveillance plan targets items believed to provide the greatest challenge to the SAVY 4000 container integrity.

Surveillance items for Fiscal Year (FY) 2020 consisted of 13 SAVY 4000 storage containers, 3 Hagan containers, and 14 SAVY 4000 transfer containers. The FY20 SAVY 4000 storage containers ranged in age from 2.4 years to 8.4 years and the Hagan containers ranged in age from 3.2 years to 15.1 years. The majority of the surveillance containers for this year were selected primarily to better understand the extent of corrosion of the stainless steel components of the containers, but also included a set of randomly selected containers over the age of 5 years. Accelerated aging studies indicate that the O-ring and filter components of the SAVY 4000 will last at least 40 years under LANL storage conditions, and surveillance test results are consistent with the conclusions from those studies. However, the observation of corrosion on the inside of SAVY 4000 and Hagan surveillance containers has shifted the emphasis to an ongoing effort to understanding both the nature and the extent of corrosion on the stainless components, primarily the container body. The restriction on handling soluble residues greater than 500 grams continued in FY19, thus limiting the ability to perform surveillance on materials that are even more challenging to the containment barrier, e.g., higher heat load, higher radiation, higher chloride content, etc. Items >500 grams that were identified for surveillance in the FY20 plan will be reconsidered for processing in FY21 and beyond.

Out of the 3 Hagan containers surveilled this year, 1 of them had to be introduced into a glovebox due to potential or actual contamination found in the containers. The data presented on this Hagan are based on the observations made by the material handler.

Unfortunately, introduction into the glovebox currently limits the ability to perform quantitative tests on the container seals, the filters, and the stainless steel components.

In FY18 a systematic categorization methodology for ranking the degree of corrosion based on photographic evidence was developed and has been applied to all surveillance containers to date. In addition to this report, the surveillance results to date are documented in four previous surveillance reports [2] [3] [4] [5] [6].

A high-level summary of the surveillance results for the SAVY and Hagan containers this year is as follows:

- **Container Integrity**— A combination of visual inspections and photographs on 13 SAVY containers and 3 Hagan containers revealed that 4 of the 13 SAVY containers and 1 of the 3 Hagan containers had corrosion. The corrosion on the SAVYs did not compromise the container integrity based on acceptable He leakage, durometer, filter and water ingress test results. Three of the SAVY containers were not returned to service due to several issue identified during surveillance. All of the 13 SAVY and 3 Hagan containers that underwent formal visual inspection passed functional checks of the closure system with no other signs of damage. The material in the Hagan containers were either processed or repackaged into SAVY containers.
- **O-rings**—O-ring visual inspections, durometer measurements and helium leakage testing were completed on all 13 SAVY and 2 of the 3 Hagan containers. All 13 SAVY containers evaluated passed the helium leakage test criteria and durometer specifications. The 2 Hagans that underwent O-ring inspections passed all of the test criteria. Helium leakage testing results also confirmed that the containment system for the 13 SAVYs and 2 of the 3 Hagans tested were fully intact.
- **Filters**—Only 12 of the 13 SAVY container filters were tested due to one of the SAVY containers being introduced in the glovebox line and an inability to test filter efficiency in gloveboxes. No issues were found with the Hagan lid filters tested. One of the SAVY filters failed the filter test criteria and was found to be damaged. Two of the 3 Hagan containers met the test criteria for aerosol capture and pressure drop indicating no degradation in efficiency and no evidence of filter clogging for those containers that were tested.
- **Water Resistance**—All containers that underwent outside of glovebox surveillance activities passed the water resistance test criteria of no water penetration after 1 minute of exposure to 12 inch water column pressure. The one filter that failed the filter test did have water ingress after a dwell time over the 1 minute called out in the water ingress procedure, Surveillance Inspections of Filter Water Resistance PA-DOP-01768.
- **Annual Surveillance and Trending Analysis**— Analysis of results on the annual testing of five surveillance containers and trending analysis (Section **Error! Reference source not found.**) of all measurements performed during surveillance testing on SAVY containers (helium leak, O-ring, durometer,

compression set, and filter performance) over the past 7 years showed no significant change in performance over this period.

Key recommendations from the FY19 surveillance report are progressing as follows:

- In FY19 a laser micrometer was introduced into a glovebox to allow for compression set measurements to be made in the glovebox line expanding the capabilities of the surveillance activities. One SAVY was introduced in FY20 which allowed the capability to be demonstrated and O-ring thickness measurements were collected.
- A strategy was developed in FY19 to incorporate a random sampling into the surveillance program, which in time will give increasing confidence that the SAVY 4000 surveillance program is identifying unforeseen container issues. A total of 7 randomly selected SAVY containers were surveilled in FY20. One of the containers that was surveilled had a damaged filter and failed the filter performance testing, showing promise in the usefulness of a random surveillance element.
- In FY20 an enhanced photographic capability was established allowing for more photos to be collected of the surveillance containers as well as photos of the unpacking process.

Recommendations from observations in this report are described in Section 6, and the FY21 version of the Surveillance Plan will be adjusted accordingly.

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1 Introduction

Approximately 1614 Storage SAVY 4000 containers are in use at Los Alamos National Laboratory (LANL), and although Hagan containers are being phased out, there are still ~2867 loaded Hagan containers in storage. The initial design lifetime for a SAVY 4000 container was 5 years, beginning in April 2014. The lifetime extension program was initiated to determine how long a SAVY 4000 container may be used safely, extending the design lifetime of the containers and avoiding unnecessary maintenance, replacement of containers or components, and handling of radioactive materials. In fiscal year 2019 an extension was granted for 10 years by the Los Alamos Field Office making the overall lifetime of the SAVY 4000 15 years [7]. The surveillance program was initiated to observe SAVY 4000 and Hagan containers during use, and information from both surveillance and lifetime extension programs is used to build a comprehensive picture of the behavior of storage containers over time.

At LANL, SAVY 4000 containers are designated as either storage containers or transfer containers as defined in the packaging procedure TA55-DOP-091, “TA-55 Nuclear Material Packaging.” The primary difference is that storage containers are certified to perform their function without maintenance over their entire lifetime, and transfer containers must be maintained annually. Once a transfer container has been used for 5 years it is more rigorously tested using the full surveillance suite, i.e. container visual inspection, O-ring visual inspection, thickness measurements and durometer testing, helium leakage rate check, filter efficiency, filter pressure drop and water ingress testing.

This work was performed in accordance with the surveillance plan, “Los Alamos National Laboratory SAVY 4000 Field Surveillance Plan Update for 2020” [1] to perform the following:

- Ensure that the containers in service are functioning properly
- Identify any unexpected problems in the containers or components and determine the causes for these problems
- Evaluate container component degradation over time against initial baseline measurements
- Contribute to the lifetime extension studies having met an initial goal of accumulating enough data within the initial 5-year design lifetime to extend the service lifetime of the SAVY 4000 container [7].

Containers with contents that represent upper bounding conditions for degradation were selected for surveillance, as detailed in the surveillance plan [1]. This report includes surveillance testing results gathered over 1 year on a total of 13 SAVY 4000 containers and 3 Hagan containers. The report also documents trending results for surveillance measurements over time.

Fiscal year 2020 was the inauguration year for a random sampling of containers over 5 years of age. This random sampling will provide a 95% confidence that a potential problem across 5% of the total population of SAVY’s will be identified. Over the next 14 years, 60 randomly selected containers will be surveilled.

2 Surveillance Examinations

This section describes the surveillance examinations of the SAVY 4000 storage and transfer containers and the Hagan containers, along with their respective O-rings and filters.

2.1 Inspection

2.1.1 Container

Inspection of the containers begins during unpacking and includes checking for external corrosion, evidence of pressurization, and dents or gouges that may have occurred during handling. The container is weighed, and a contamination survey is conducted before the container is opened. When the container is opened, the bag-out bag is inspected for signs of compromised integrity such as discoloration, brittleness, or the presence of liquid and the interior of the outer container is surveyed for contamination. The packaging configuration is verified for compliance with facility requirements, and the outer container is checked for corrosion or the presence of liquid. The visual inspection continues when the outer container is emptied and then released to the package-engineering team for further evaluation. The empty container is then checked for proper function of the closure mechanism, damage to the O-ring groove in the lid or on the body collar's sealing surface, filter discolorations or occlusions, and evidence of corrosion. If deemed necessary by a subject matter expert, the weld at the collar-body interface may be tested as well, but no welds were tested during the past years.

2.1.2 O-ring

Visual inspection of each O-ring was conducted according to PA-DOP-01080 Rev.1, "Surveillance Inspections of O-Rings for Nuclear Material Storage Containers," using a 4-inch, illuminated magnifying lens to look for O-ring defects such as flashing; mold mismatch; damage to the O-ring, such as cuts or abrasions; and the presence of dirt, hair, or dust on the O-ring. Irregularities were noted on the inspection sheet and corrected by cleaning, if possible.

2.2 Tests

2.2.1 Helium Leakage Rate

The leakage rate for each SAVY 4000 container with its original O-ring installed was measured in the inside-out mode using a LACO Flexstation™ bell-jar helium mass-spectroscopy leakage tester according to the procedure in PA-AP-01158 Rev. 0, "Helium Leakage Test Procedure of the SAVY 4000." The leakage tester detects the presence of a leakage by analyzing for helium leakage into a bell jar held near vacuum when the container is charged with 75 Torr of helium.

The O-ring passes the leakage test if the measured leakage rate is below a threshold value of 1×10^{-5} atm cc s⁻¹. That threshold value was determined for leakage rate testing of

SAVY 4000 container O-rings in Section 5.2 of the SAVY 4000 safety analysis report [8].

A single-point calibration is done before the measurements are taken each day. During FY20, the calibration standard used had a value of 1.05×10^{-7} atm. cc/s. This value is low enough to ensure that a leakage at the threshold value will register on the leakage detector, but it is high enough to be distinguishable from the typical background leakage rate.

The sensitivity of the measurement is limited by the quantity of helium in the ambient atmosphere, which can come from helium diffusing out of porous parts in the leakage tester from prior tests. This helium contributes to an apparent background leakage rate. A background measurement was taken before each measurement.

Beginning in FY20 an in-glovebox helium leak test capability was established. One SAVY was used to demonstrate this new capability, 20S9(203). The in-glovebox capability differs in how it is performed compared to the out-of-glovebox capability. The in-glovebox helium leak capability is performed by pulling a vacuum on the container being tested and helium is sprayed around the container, whereas the out-of-glovebox capability uses a bell jar that surrounds the container being tested and a vacuum is pulled outside of the container as the container being tested is filled with helium. The in-glovebox helium leak capability is not currently capable of providing a quantitative leak rate but rather a pass or fail result.

2.2.2 O-ring Hardness

The hardness of each O-ring was measured by durometer, according to PA-DOP-01080 Rev. 1, "Surveillance Inspections of O-Rings for Nuclear Material Storage Containers," on the Shore-M scale. The hardness value for each O-ring was taken as the average of five durometer measurements taken at arbitrary but different positions around the whole O-ring. The calibration of the durometer is checked before and after each day of surveillance testing, using known calibration hardness standards.

2.2.3 O-ring Compression Set

The compression set of the O-rings used in the storage containers was estimated from a measurement of the O-ring thickness several weeks after they were removed from their containers as part of the SAVY 4000 surveillance program. The initial thickness of the O-rings was 5.333 ± 0.045 mm, derived from the average of 85 unused O-rings, measured three times each. The compressed thickness was taken to be the gland depth of the container, which was determined by finding the best value for the difference between the lid sealing diameter and the collar sealing diameter, measured as part of the inspection process. If measurements were unavailable, the mean value for that particular batch and size of container was taken from those surveyed in the receipt inspections. The final thickness measurement was taken by suspending the O-ring within the beam of a laser micrometer and averaging eight measurements at arbitrary positions around the O-ring. The uncertainty varied with the precision of the values available for each calculation, but generally was in the range of 5%–8%.

Beginning in FY20 an in-glovebox capability was established and the first measurements were made on one SAVY. The SAVY that was used to demonstrate this new capability was 20S9(203). The measurement technique is identical to the technique used to measure O-rings outside of the glovebox.

2.2.4 Filter Efficiency

Thirteen SAVY and three Hagan filters were subjected to particle penetration testing, in which the concentration of a test aerosol is measured downstream of the filter per PA-DOP-01580 Rev. 1. The test aerosol used was polyalpha-olefin with a concentration of 65 ± 15 $\mu\text{g/L}$ upstream of the filter. The concentration was measured using an Air Techniques International (ATI) 2H photometer, which was modified by ATI for the test flow rate of 200 cc/min. The filters must capture at least 99.97% of the challenge aerosol. The development of this instrument and calibration information is discussed in LA-UR-16-20507, "Development and Use of a Low-Flow Filter Test System for the Filters Used in Special Nuclear Material Storage Containers".

2.2.5 Filter Pressure Drop

Thirteen SAVY and three Hagan filters were subjected to pressure drop testing per PA-DOP-01580 Rev. 1. The pressure drop tests were performed in conjunction with the aerosol tests. After the upstream aerosol concentration is measured, the instrument is switched to measure the concentration downstream of the filter, where the data system records 15 pressure drop data values in one-second intervals. The first two data points are discarded because there is an interval with a momentary spike in the system pressure. The pressure drop must be less than 1-inch of water column at a flow rate of 200 cc/min to be considered passing.

2.2.6 Water Penetration Testing

A selection of SAVY 4000 containers underwent water penetration testing using PA-DOP-01768, "Surveillance Inspections of Filter Water Resistance". A pressure of water at 12" water column was applied to the filter on the outside of the lid and the pressure was held for 1 minute. The opposite side of the filter was monitored during the 1 minute interval to check for any water penetration. If no penetration was observed, the filter was considered to have passed the test. This test is comparable to the water penetration test performed at the time of container manufacture.

2.2.7 Corrosion Evaluation

The visual inspection of SAVY 4000 and Hagan containers includes an evaluation of the corrosion found on container surfaces. Any corrosion observed during the visual inspection is documented and photographed. In an effort to better understand the conditions under which corrosion occurs, a numeric ranking was assigned to each surveillance container from FY13 through FY20. The numeric ranking (Table 1) describes the severity of the corrosion based on its overall appearance with consideration for the relative coverage and density of the corrosion. The numeric ranking ranges from 0 (no corrosion) to a ranking of 3 (the most severe) [9]. The ranking can be used to

compare the corrosion behavior for various material forms and material types as well as to assess the progression of corrosion over time.

Table 1. Numeric Ranking for General Corrosion in SAVY 4000 and Hagan Containers

Numeric Ranking	Description	Criteria
0	No Corrosion	No corrosion, staining, spots, or coatings observed
1	Isolated General Corrosion	Corrosion, staining, spots, or coatings observed in isolated areas (e.g., corrosion found on weld only)
2	Light General Corrosion	Corrosion, staining, spots, or coatings throughout container; light in overall density; bare metal visible
3	Heavy General Corrosion	Corrosion, staining, spots, or coatings throughout container; heavy (dark) in overall density; little or no bare metal visible

3 Materials and Containers

For FY20 surveillance, the selection criteria for SAVY containers were updated based on the corrosion identified in previous years. Containers were selected based on the material form (e.g., radiation, corrosivity or gas generating potential), wattage (e.g., high Am), container size (e.g., ≤ 5 Qt) and the age (e.g., as old as possible) of the containers. The age of the containers reported below was calculated as the time between the initial packaging and the date of the surveillance measurements. The history of the material form was also considered, e.g., items were included which had previously been found to cause corrosion. In addition to these criteria, seven SAVY containers were selected randomly as described in the 2020 Update [1].

From the 2017 surveillance plan through 2020 Hagan containers have been evaluated as part of SAVY surveillance. These containers were added due to the age of the containers, the similar material of construction (304L for Hagan, 316L for SAVY 4000), and the fact that the containers are still in storage and likely will be for at least a decade. In addition, the 316L components of the SAVY 4000 containers are expected to be more corrosion resistant than 304L components of the Hagan containers providing bounding results for the SAVYs.

Table 2 provides a roadmap of all the containers tested. Where available, the SN for the SAVY-4000 container packaged with the material originally packaged inside the Hagan container is included. Also included in the table are the container ages and the thermal power. The plutonium mass ranges from 4 g to 4246 g. The physical and chemical forms cover a broad range, including compounds (Pu dioxide and Pu chloride), metals (unalloyed Pu metal), and process residues (filter residue, direct oxide reduction [DOR] salt, incinerator ash, ER salt, and molten salt extraction [MSE] salt) as well as Uranium items. The isotopic compositions of the materials range from weapons grade Pu (MT 52) to fuel grade Pu (MT 54-57), high americium items (MT 5X+44, MSE salts), and heat source Pu (MT 83). The thermal power ranges from 0 W to 19.7 W. The age (time in

service) of the Hagan containers ranges from 4.8 to 19.4 years, and the age of the SAVY 4000 containers ranges from 0.84 to 8.4 years (over the entire surveillance program).

Table 2. Roadmap for the Hagan and SAVY 4000 surveillance containers and their contents

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
13H1	2013	MSE Salt	52+44	CAXBL128D	8/02 LANL-813, 30142	11110 3026	835	8.55	13.4	2
13H2	2013	ER Salt	52	GBS005	4/02 A-28, 04/02-08028	04120 8025	1875	8.22	4.9	1
13H3	2013	ER Salt	52	GBS059	4/02 A-207, 04/02-08010	04120 8004	1877	8.22	4.9	2
13H4	2013	Incinerator Ash	54	INCA-20	4/99 LANL-429, 05/99 NMC 08000-305	04120 8043	830	7.93	3.4	2
13H5	2013	Incinerator Ash	54	INCA-21	4/99 LANL-405, 04/02-08145	04120 8009	913	8.3	3.8	2
13H6	2013	MgO	52	ORF633956X BLC	2/99 LANL-83, 80208	04120 8038	248	13.17	0.7	n/a
13H7	2013	Salt	52	PCS68B1	4/02 A-134, 08/06-08077	04120 8028	811	4.82	2.1	n/a
13H8	2013	Tetra-fluoride	54	PHX5R4	8/05 LANL-2282, 08/05-03282	12110 3052	166	6.45	0.7	0
13H9	2013	Sweepings/Screenings	52	POX4275C1	7/02 LANL-393, 06/02-05183	09120 5182	1037	7.56	2.73	0
13H10	2013	Dioxide	56	RBXS5657-1A	7/02 LANL-515, 06/02-05305	04120 5026	751	8.81	3.8	2

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
13H11	2013	DOR Salt	52	SLTF3123A	8/99 LANL-1178, 07/02-03184	12110 3062	1900	7.84	5	0
13H12	2013	Salt	52	SWPVTB15	08/02 LANL-897, 08/05-03300	11110 3001	678	5.77	1.8	n/a
13H13	2013	Sweepings/Screenings	52	VTB-16C1	4/02 A-164, 04/02-05164	02120 5029	1013	7.49	2.7	n/a
13H14	2013	MgO	52	XBLC9413	2/99 LANL-80, 80207	04120 8055	356	13.34	0.9	n/a
13H15	2013	MSE Salt	56+44	XBLS25	10/99 LANL-1932, 80234	04120 8031	430	7.84	12.4	n/a
13H16	2013	DOR Salt	52	XBSOX153	3/06 LANL-296, 03/06-05296	09120 5175	1079	6.33	2.84	0
15H1	2015	Dioxide	52	MOX51T	8/99-LANL-1277, 06/02-05305	12110 3054	2355.6	14.43	6.2	2
15H2	2015	ER Salt	52	XBS9455	5/01-LANL-53, 08/99NMC03-000-125	12110 3078	382.5	12.36	1	1
15H3	2015	Dioxide	57	BLO-39-11-16	3/01-LANL-209,	11130 8080	544	5.62	5	3
15H4	2015	Dioxide	56	RBXS5657-2A	LANL-441, 04/02-08049	08130 5197	2059	11.48	10.5	3
16H1	2016	Dioxide	54+44	XBPS333	N/A	N/A	80	8.1	2.9	3

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
17H1	2017	Chloride	52	ATLAMS1S1	07/02-03259 8/02 LANL-1014	N/A	75	11.10	0.2	2
17H2	2017	Chloride	52	CASLT966	0702-03261 LANL1061	N/A	286	12.02	0.6	1
17H3	2017	Filter Residue	52	CXLRES091 599	05/99-NMC05-000-079, LANL-45	N/A	75	17.58	0.4	0
17H4	2017	Incinerator Ash	52	ASHX09	05/99-NMC03-000-192, LANL-1344	N/A	4	16.16	0	0
17H5	2017	Dioxide	83	10/10-01076 (Pu238)	10/10-01076 10-10 LANL-418	N/A	(blank)	6.27	19.7	1
17H6	2017	ER Salt	52	XORER6SLT 2	0402-08245 A245	N/A	457	11.63	1.2	0
17H7	2017	MSE Salt	56	XBLS8A	0805/03142 LANL2139	N/A	114	10.67	3.5	2
17H8	2017	MSE Salt	52	XBSoX448A	08/06-01050 06/00 LANL-98	N/A	56	17.41	0.9	n/a
18H1	2018	Residue; Incinerator Ash	83	TDC175	9/99 NMC05 LANL-1707 9/99NMC05000-392	N/A	N/A	17	10.3	1
18H2	2018	ER Salt	52	XBS9409	2/99 LANL-88	N/A	445	16.8	1.2	0
18H3	2018	ER Salt	52	XBS0C6	2/99 LANL-35 080159	N/A	328	16.8	0.9	0

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
18H4	2018	MSE Salt	52	XBLS1124	LANL 120 3/06 03/ 06-05120	N/A	110	6.2	0.45	2
18H5	2018	MgO Crucible	52	XBLC6380	4/02 A-91 04/ 02-08091	N/A	210	10.5	0.6	0
18H6	2018	DOR Salt	52	SLT1802	10/99 LANL-1987 8Qt-70	N/A	209	16	0.6	1
18H7	2018	MSE Salt	52	XBLSCL405 1203	8/02 LANL-763 08/ 02-01163	N/A	451	13	6.9	3
18H8	2018	MSE Salt	52	XBLSCL121 0	10/10 LANL-204 10/10-03064	N/A	432	6	6.9	0
19H1	2019	Unalloyed Metal	42	GRING18	NMC03-030412 LANL-2476	12110 3092	2165	19.4	14.9	3
19H3	2019	Incinerator Ash	83	TDC153	NMC08000-318 LANL-442	N/A	24.5	18.3	11.6	3
19H5	2019	MSE Salt	52	XBLSCL160 6	6-00 LANL-180 1QT-180	02180 5118	356	12.4	5.7	3
19H7	2019	Multiple Alloys or Contaminant	51	DAS743700	NMC05000-42 LANL-635	05170 8066	679	18	1.5	2
20H11	2020	Dioxide	52	PSP67156WP HOX	03-06-05195 LANL-195 3-06	02180 5042	2440.07	3.22	6.42	0

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
20H12	2020	Dioxide	52	BMB2C4	800008 LANL-1454	N/A	1520	3.4	4	1
19IoOP 45	2019	MSE Salt	56	XBLS11A	03-05-05274 LANL-274		143	12	4.2	0
19IoOP 46	2019	MSE Salt	56	XBLS6A	04-02-08270 NUCFIL-013 4-06A-270		154.3	13.9	4.8	1
19IoOP 50	2019	Multiple Alloys or Contaminant	51	DAS743800	NMCO05000-226 LANL-1501		674	18	1.5	1
19IoOP 55	2019	MSE Salt	56	XBLS5A	03-06-0531 LANL-351306		105	12.7	3.2	2
19IoOP 56	2019	MSE Sale	55	XBLS4A1	03 06-05072 LANL-691		75	11.2	2.1	3
20IoOp 1	2020	Dioxide	56	LAO225BS	0602-05010 LANL-220-702	N/A	887	15.08	3.96	0
15S1	2015	Dioxide	52	CXLOX0829 11	N/A	03110 5052	786.9	3.03	2.07	0
15S2	2015	MSE Salt	52+44	XBLSCL121 7	N/A	12110 3083	178.5	1.86	2.85	0
15S3	2015	Unalloyed Metal	53	XAP6	N/A	03110 5002	69.5	3.01	0.21	0
15S4	2015	Filter Residue	52	ROTRBJ-1C1	N/A	03110 5051	452	3.46	1.19	0
15S5	2015	MgO	52	XBLC9413	2/99 LANL-80, 80207	04120 8055	913	1.96	2.4	0

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
15S6	2015	Tetra-fluoride	54	PHX3F	N/A	12110 3121	479.2	1.8	1.98	0
15S7	2015	Tetra-fluoride	54	PHX5R4	N/A	12110 3052	166	2.37	0.7	0
15S8	2015	MSE Salt	56+44	XBLS25	10/99 LANL- 1932, 80234	04120 8031	430	2.55	12.4	0
15S9	2015	Dioxide	54	PBO	N/A	03110 5028	1330.8	3.57	5.5	2
15S10	2015	Dioxide	56	RBXS5657- 1A	7/02 LANL- 515, 06/02- 05305	04120 5026	751	2.65	3.8	2
16S1	2016	Non-Actinide Metal	53	SCRES65B	N/A	03110 5064	718	4.18	2.2	0
16S2	2016	DOR Salt	52	SLT1303	N/A	04120 8034	391.9	3.08	1	0
16S3	2016	Unalloyed Metal	52	PMP91308	N/A	11130 8040	3220.6	0.84	8.5	0
16S4	2016	MSE Salt	52+44	XBLSCL112 0A	N/A	12110 3041	155.1	3.22	2.5	0
16S5	2016	Filter Residue	52	ROTRB9C3	N/A	03110 5039	500	4.87	1.3	0
16S6	2016	MSE Salt	52+44	XBLSCL121 3	N/A	02120 5021	377.03	3.24	6.03	2
16S7	2016	Unalloyed Metal	52	ARIAAQ137	N/A	09120 5173	2456.68	3.32	6.5	0

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
16S8	2016	Dioxide	52+83	AAP02OX	N/A	04120 8057	509.4	3.4	21.28	3
16S9	2016	MSE Salt	52+44	XBLSCL130 2	N/A	12110 3057	199.32	3.4	3.2	0
16S10	2016	MSE Salt	52+44	XBLSCL130 1	N/A	12110 3044	192.6	3.4	3.1	0
16S11	2016	Dioxide	52	CXLOX0829 11	N/A	03110 5052	786.9	4.14	2.07	0
16S12	2016	Unalloyed Metal	53	XAP6	N/A	03110 5002	69.5	4.12	0.21	0
16S13	2016	Filter Residue	52	ROTRBJ- 1C1	N/A	03110 5051	452	4.58	1.19	0
16S14	2016	MSE Salt	52+44	XBLSCL121 7	N/A	12110 3083	178.5	2.96	2.85	0
16S15	2016	Dioxide	83	GPHS	N/A	07120 1061	120	2.76	60.49	0
17S1	2017	Dioxide	57	BLO-39-11- 16	N/A	11130 8080	544	1.61	5	2
17S2	2017	Dioxide	52	CXLOX0829 11	N/A	03110 5052	786.9	5.16	2.07	0
17S3	2017	Unalloyed Metal	53	XAP6	N/A	03110 5002	69.5	5.15	0.21	1
17S4	2017	Filter Residue	52	ROTRBJ- 1C1	N/A	03110 5051	452	5.59	1.19	1
17S5	2017	MSE Salt	52+44	XBLSCL121 7	N/A	12110 3083	178.5	3.98	2.895	1

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
17S6	2017	DOR Salt	52	SLT1303	N/A	11130 8050	391.9	1.03	1	0
17S7	2017	Incinerator Ash	52+54	INC20602	N/A	11110 3020	31	4.67	0.1	0
17S8	2017	Unalloyed Metal	53	XAP6 (outer)	N/A	11130 8059	69.5	1.02	0.21	0
18S1	2018	Compound; Dioxide	57	BLO-39-11- 16	N/A	11130 8080	544	2.4	5	2
18S2	2018	Compound Residue	52	CXLOX0829 11	N/A	03110 5052	787	6.1	0.1	0
18S3b	2018	Unalloyed Metal	53	XAP6	N/A	11130 8059	69	2	0.21	0
18S4	2018	Dioxide	52	ROTRBJ- 1C1	N/A	03110 5051	452	6.6	1.2	1
18S5	2018	MSE Salt	52 + 44	XBLSCL121 7	N/A	12110 3083	178	4.9	2.9	1
18S6	2018	DOR Salt	52	SLTF3123A	N/A	12110 3062	1900	5.4	2.9	1
18S7	2018	Dioxide	83	SAMPCAN2	N/A	09120 5130	N/A	3.8	16.6	2
19S1	2019	Dioxide	57	BLO-39-11- 16	N/A	11130 8080	544	3.70	5	2
19S2	2019	Dioxide	52	CXLOX0829 11	N/A	03110 5052	786.9	7.4	2.1	0
19S3	2019	MSE Salt	52+44	XBLSCL121 7	N/A	12110 3083	178.5+10. 6	6.4	2.9	1

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
19S4	2019	Filter Residue	52	ROTRBJ-1C1	N/A	031105051	452	7.9	1.2	1
19S5	2019	Unalloyed Metal	53	XAP6 (Outer)	N/A	111308059	69.5	3.46	0.2	0
19S6	2019	Unalloyed Metal	53	XAP6 (Inner)	N/A	031105002	69.5	7.60	0.2	0
19S9	2019	Sweepings/Screenings	52	POX4275C1	N/A	091205182	1037.4	6.4	2.7	0
19S10	2019	Salt	52	SWPVTB15	N/A	111103001	678	6.5	1.8	0
19S11	2019	DOR Salt	52	XBSOX153	N/A	091205175	1079	6.4	2.8	1
19S13	2019	Dioxide	56	RBXS5657-2A	N/A	081305008	2059	3.8	10.5	2
20S6 (32)	2020	Alloyed Metal	52 82	HNN5216CF	N/A	021205013	2125	8.44	5.6	1
20S7 (75)	2020	Unalloyed Metal	52	PMP71205B	N/A	041205019	535	7.66	1.41	1
20S8 (108)	2020	Dioxide	38	1153-3A	N/A	041205009	0	7.5	0	0
20S9 (119)	2020	PROCESS RESIDUE;DOR Salt	52	XBSOX153	N/A	091205175	1061	7.47	2.84	2
20S9 (132)	2020	Dioxide	52	SCP-1741A	N/A	121101026	371	7.44	0.98	1
20S9 (174)	2020	DOR Salt	52	SLT1304	N/A	041208067	699	7.39	1.84	0
20S9 (203)	2020	Unalloyed Metal	52	R700121	N/A	041208030	4246	6.04	11.18	0

Surv #	FY	Chemical Subform	Material Type	Material Name	Hagan SN	SAVY SN	Pu-239 (g)	Container Age (y)	Thermal Power (W)	Corrosion Ranking
20S10	2020	Dioxide	52	LZB225-RM640	N/A	08130 5233	2295.33	3.33	6.04	0
20S12	2020	Dioxide	52	BMB21OXC 1	N/A	08130 5262	2270.05	3.31	5.98	0
20S13	2020	Dioxide	52	CASKL2143	N/A	08130 5181	2256.42	3.31	5.94	1
20S14	2020	Dioxide	52	LZB223-RS- 183	N/A	02160 8089 B 02160 8129 L	2177.5	3.31	5.73	0
20S15	2020	Dioxide	52	CXPROD192	N/A	11130 8078	893	2.42	2.35	0
20S16	2020	Dioxide	83	UAS-2634- K88, UAS- 2647- K88,UAS- 2909- H89,UAS- 3020- B90,UAS- 2732-E89	N/A	07120 1046	35.4	4.39	16.9	0

Transfer containers are also subject to surveillance activities throughout their maintenance cycle, and although they are not surveillance items “per se” the inspection and test data are documented at the end of each FY. Transfer containers are intended primarily for transfer of nuclear material throughout the facility that are out of scope of the SAVY SAR. They may be stored for up to one year, at which point the containers must be inspected by the container management team.

The container management team continues to practice the new lifecycle protocol of the transfer container set in FY19. The lifecycle extension has been documented in MEMO SPE-2 19:003 which states that surveillance testing will be conducted every 5 years but an annual visual inspection will still be conducted upon the one year transfer label expiration date. The visual inspection is based on container integrity and the judgment of the Container Management Team per PA-DOP-01080, which includes visual inspection for dents, discoloration, corrosion, functional checks of the closure mechanism and other defects inside and outside of the container that may cause the SAVY-4000 not to function as designed. The visual inspections will be conducted each year until the 5 year visual examination is exhausted at which point the container will undergo a full surveillance. The 5-year cycle restarts the date of the last full surveillance testing. Table 3 below shows the transfer containers that were maintenance cycled due to the transfer container being outside is 5 year visual inspection date. Observations to note are container 081305044, which failed O-ring visual inspection with respect to a cut on the sealing face of the O-ring, the O-ring was removed and replaced with a new O-ring and surveillance testing was continued with the new O-ring. All other containers passed all surveillance testing. Due to the way transfer containers are utilized, information about contents, dates of packaging, etc., are not recorded.

Table 3 Transfer containers visually inspected in FY20.

Transfer Container Sample Number	SAVY 4000 Serial Number	Date of Transfer Container Creation	Age at maintenance cycle (~years)	Number of Completed Maintenance cycles
1T	031403057 B/L	5/11/15	4.5	3
2T	071701170B 031702057L	12/13/17	2	1
3T	111501076 B/L	9/28/16	3.2	1
4T	071701141 B/L	12/13/17	3	1
5T	071701159 B/L	12/13/17	3	1
6T	091205131 B/L	4/7/17	2.5	2
7T	071701066 B/L	9/12/19	<1	1
8T	081305044 B/L	7/12/16	2.3	3
9T	031403177 B/L	9/25/15	4.7	1
10T	071201137 B/L	6/8/15	5	2
11T	031712193 B/L	6/25/20	<1	1
12T	031712023 B/L	6/25/20	<1	1
13T	011705165 B/L	1/2/18	2.4	1
14T	031403124 B/L	5/11/15	5	1

4 Results

4.1 Hagan Containers

Surveillance was performed on 3 Hagan storage containers in FY20. The surveillance test results are given in Table 4. All three surveillance Hagan containers had completed unpacking data forms. One of the Hagan containers was introduced into the glovebox line due to the concern of having a failed bag-out bag. Two of the Hagan containers had the filter particle penetration, filter pressure drop, O-ring durometer, water penetration and the helium leakage tests performed. The surveillance results are presented below.

Item of opportunity 20IoOP1 was surveilled inside of the glovebox and therefore does not have measurements for helium leak rate, filter particle penetration, filter pressure drop and durometer values listed in the following sections.

4.1.1 Visual Inspections

Corrosion was observed in one of the three Hagan containers that had surveillance performed in FY20. Container 20H12 packaged with Pu oxide item had light corrosion on the inside surfaces of the container from the degradation of PVC bag. Container 20H11 was in a pristine condition. The bag out bag inside of 20H11 was slightly discolored, but still pliable.

Table 4. Surveillance test results for Hagan storage containers.

ID	Container Serial No. and Size	Container Visual Inspection	Corrosion Ranking	O-Ring Visual Inspection	Material Name and IDC	Sample Power (W)	Package Age (y)	Filter Particle Penetration (%) ± 0.0002	Filter Pressure Drop (in W.C) ± 0.02	Helium Leakage Rate ($\frac{atm-cc}{s}$)	O-ring Durometer (Shore M) ± 2.15
20H11	03-06-05195 LANL-195 3- 06 5 Quart	Nothing of note	0	Dust wipes away the o-ring is still ok	PSP67156WPHOX C211	6.42	3.22	0.0119	0.394	3E-07	74.1
20H12	800008 LANL-1454 8 Quart	Small amounts of corrosion inside the container body	1	O-ring was cut during removal container is NCR'd	BMB2C4 C217	4	3.4	0.0114	0.567	3.4E-07	73.4
20IIOp1	0602-05010 LANL-220- 702 5 Quart	Nothing of note	0	Some grease on o-ring, still ok	LAO225BS C213	3.96	15.08	N/A	N/A	N/A	N/A

4.1.1.1 Hagan Container, Surveillance, Sample #20H11, Body: 03-06-05195 Lid: LANL-195 3-06, PSP67156WPHOX, MT52, 2440.0 g Pu, C21, Oxide 6.42 W, 3.22 years

Container 20H11 was loaded with MT52 (Pu-239) oxide. The material was packaged in a stainless steel slip-lid container. The inner container did have some corrosion on the exterior surfaces. A small amount of bag residue was seen on the inner surfaces of the Hagan. The Hagan container appeared pristine upon visual inspection, and passed all surveillance tests. The contents were repackaged into a SAVY container SN: 021805042.

Table 5. Unpacking data for Sample 20H11 (based on photographs and filled out unpack form)

Surveillance sample number	20H11
Person performing the repack	Christopher Adan Herrera
Date of Unloading	12/12/2019
SAVY 4000 or Hagan Serial #'s:	Body:03-06-05195
	Lid: LANL-195 3-06
Overall Package Weight Before Unloading:	2912.70
Outer Container Condition:	Good
Pewter Outer Shielding present?	No
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes (Photo)
Pewter Internal shielding present?	No
Condition of bag out bag?	Good
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Stainless Steel Slip Lid
Item content verification:	PSP67156WPHOX
Condition of inner container?	Small corrosion on the outside of the slip lid
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not Noted
Comments:	Item will be repacked into SAVY-4000 SN 021805042 B/L repack will have external shielding. Alpha-Beta-Gamma-11 mrem/hr on contact, 4 mrem/hr Neutron on contact (of repacked item)

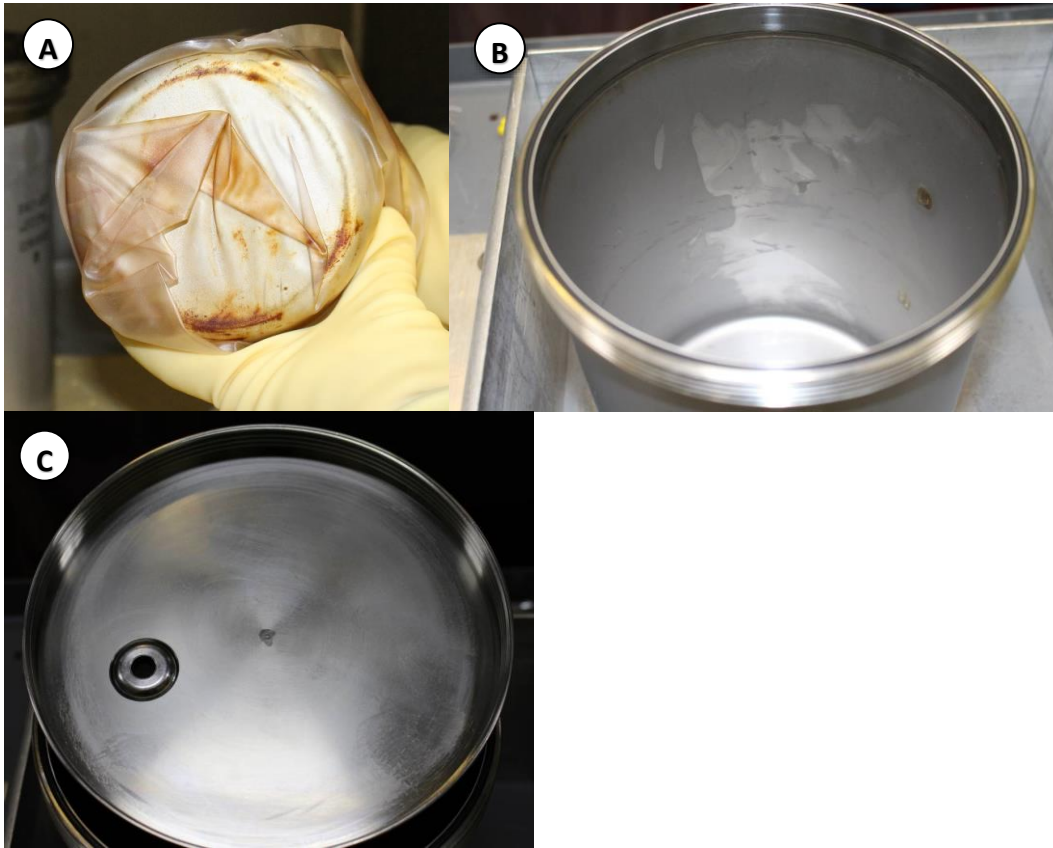


Figure 4-1 Visual Inspection for 20H11 shows relatively pristine Hagan. (A) Corrosion seen on exterior surface of inner slip-lid container. (B) Inside of Hagan and installed O-ring. (C) Inside of lid and sealing surface.

4.1.1.2 Hagan Container, Surveillance, Sample #20H12, 800008 LANL-1454, BMB2C4, MT52, 1520.00 g Pu, C21, Oxide, 4.0 W, 3.36 years

Container 20H12 was loaded with MT52 (Pu-239) oxide. The material was packaged in a stainless steel slip-lid container. A small amount of bag residue was seen on the inner surfaces of the Hagan along with small areas of corrosion. The Hagan passed all surveillance tests. As the container was being introduced it was identified to be a Hagan with an NCR according to TA55-DOP-091, *Nuclear Material Packaging*.

Table 6. Unpacking data for Sample 20H12 (based on photographs and filled out unpack form)

Surveillance sample number	20H12
Person performing the repack	Brandon Williams
Date of Unloading	124/19
SAVY 4000 or Hagan Serial #'s:	Body: 800008
	Lid: LANL-1454
Overall Package Weight Before Unloading:	2000.0 g
Outer Container Condition:	Good (photo)
Pewter Outer Shielding present?	No
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes (photo)
Pewter Internal shielding present?	Not noted
Condition of bag out bag?	Good
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Taped Stainless Steel Slip Lid
Item content verification:	BMB2C4
Condition of inner container?	Good
Will bag-out bag be replaced before re-pack?	Not noted
Will inner container be replaced before re-pack?	Not noted
Overall package weight after repack:	Note noted
Comments:	Alpha-Beta-Gamma-5 mrem/hr on contact, 3.7 mrem/hr Neutron on contact



Figure 4-2 Visual inspection of 20H12 (A) Corrosion on inner surface of Hagan container. (B) Metallic label on the container body.

4.1.1.3 Hagan Container, Item of Opportunity, Sample #20IofOP1, 0602-05010 LANL-220-702, LAO225BS, MT56, 887 g Pu, C21, Compound Dioxide, 4 W, 15.0 years

Container 20IofOP1 was packaged with 1 kg of high-purity plutonium dioxide. The material was produced in 1982 by the peroxide precipitation process at LANL and packaged into nested crimp-sealed containers. The inner most crimp-sealed container was placed in a polyethylene bag and placed in the outer crimp-sealed container. The outer crimp-sealed container served as the outer container from the time the material was produced until it was loaded into a Hagan container in 2005. The plutonium has an isotopic composition consistent with MT 56; however, the americium content is low relative to other MT 56 materials at LANL because the americium was removed in production.

The condition of the Hagan container was like new, and the Hagan body showed only slight discoloration in areas surrounding the welds, which is consistent with the coloration of heat affected zones in new Hagan bodies. The outer and inner crimp-sealed containers were in good condition and did not have corrosion. The lack of corrosion in the Hagan container may be explained by the use of polyethylene bags rather than PVC, which degrades and produces corrosive gases. The material was high-purity plutonium oxide and did not have chloride salts in the material matrix. The PVC tape on the horsetail of the outer bag was the only PVC in the container, but it was exposed to little or no alpha contamination.

The outer polyethylene bag was in good condition and was still pliable; however, the inner polyethylene bag was almost completely disintegrated. These observations suggest that alpha contamination may be one of the environmental factors resulting in differences between similarly packaged containers. In the case, both bags were exposed to with gamma radiation from the plutonium, but only the inner PE bag was exposed to alpha contamination. The temperature differences between the bags would have been similar. However, the outer polyethylene bag was exposed to little or no contamination because the outer crimp-sealed container would have been contamination free intended to be an outer container at the time of packaging to serve as the outer container. Therefore, alpha irradiation was the likely cause of the degradation of the inner polyethylene bag.

Table 7. Unpacking data for Sample 20ILOp1 (based on photographs)

Surveillance sample number	20ILOp1
Person performing the repack	Joshua Narlesky
Date of Unloading	8/12/20
SAVY 4000 or Hagan Serial #'s:	Body: 06/02-05010
	Lid: LANL-220-7/02
Overall Package Weight Before Unloading:	6365.3 g
Outer Container Condition:	Good
Pewter Outer Shielding present?	No
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	Yes, Lead Inner Shielding
Condition of bag out bag?	Like new
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Nested crimp seal containers
Item content verification:	LAO225BS, MT 56, NM (g) 887
Condition of inner container?	Good, Loaded 7/28/2005
Will bag-out bag be replaced before re-pack?	Yes
Will inner container be replaced before re-pack?	No, Material introduced for production
Overall package weight after repack:	No, Material introduced for production
Comments:	Inner configuration. nested crimp seal cans. Innermost crimp seal was bagged, but PE bag was destroyed. Outer crimp seal container had PE bag that was like new. Hagan introduced. Material used for processing.

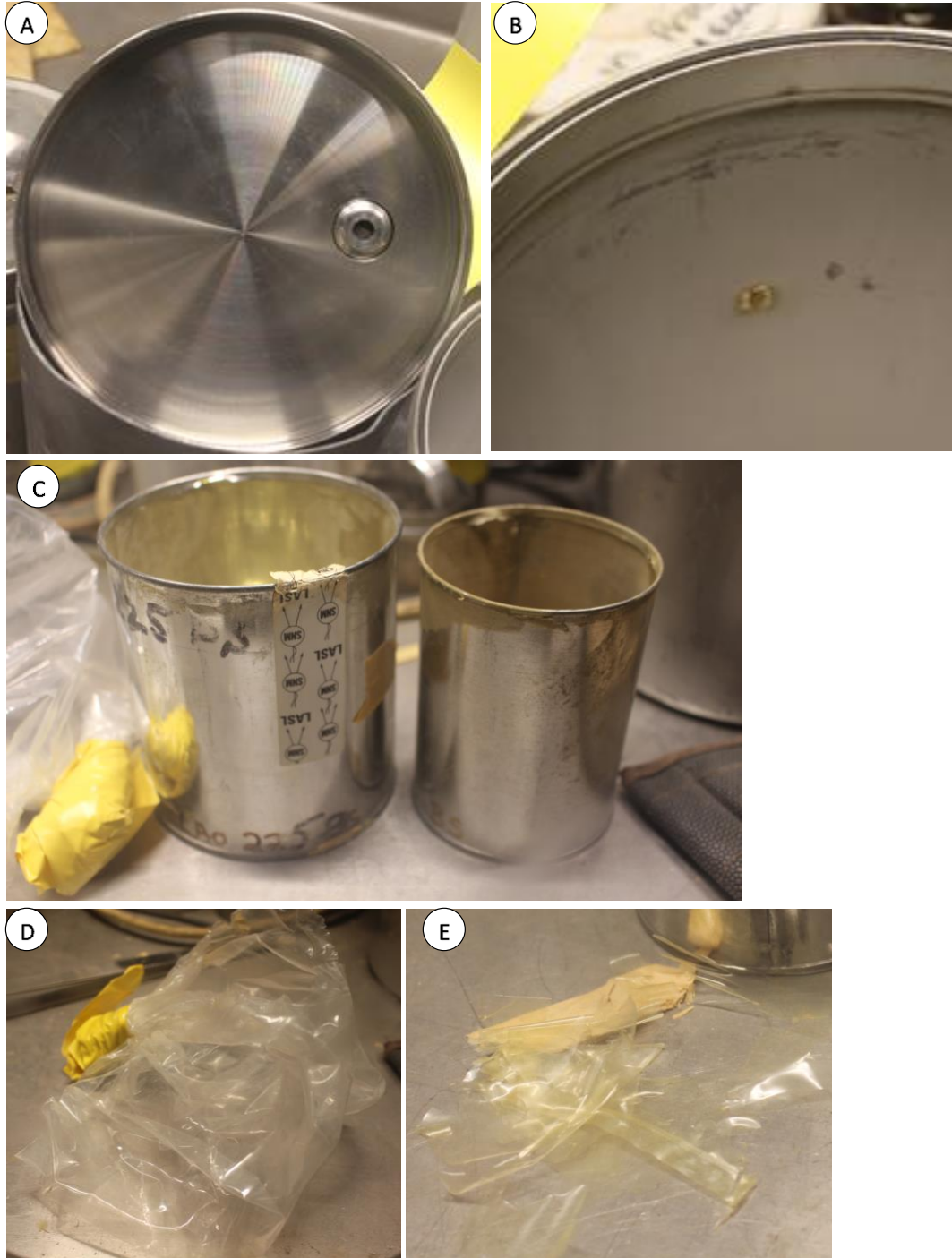


Figure 4-3 Visual inspection of 20lofOp1 (A) Condition of Hagan lid is like new. (B) Hagan body has slight discoloration in heat affected zones around welds. (C) Nested crimp-sealed inner containers (D) Polyethylene bag that was placed around outer crimp-sealed container (E) Polyethylene bag that was placed around inner crimp-sealed container had disintegrated.

4.1.1.1 Leakage Rate Tests

The leakage rate results for the Hagan storage containers are shown in Figure 4-4 for all Hagan containers measured between FY15 and FY20. The measured leakage rates are shown in atm-cc/s of helium at 75 Torr into vacuum. One O-ring failed the leakage test each in FY17, FY18 and FY19, with a measurement above the failure criterion of 1×10^{-5} atm cc/s, possibly resulting from the O-ring hardness being out of specification or the amount of compression set. Due to the Hagan's design and lack of historic data on O-ring thicknesses, it is not possible to acquire a compression set measurement. Because the Hagan is designed with a threaded lid that can be closed to different degrees, it makes it difficult to determine what the gland size is for each container.

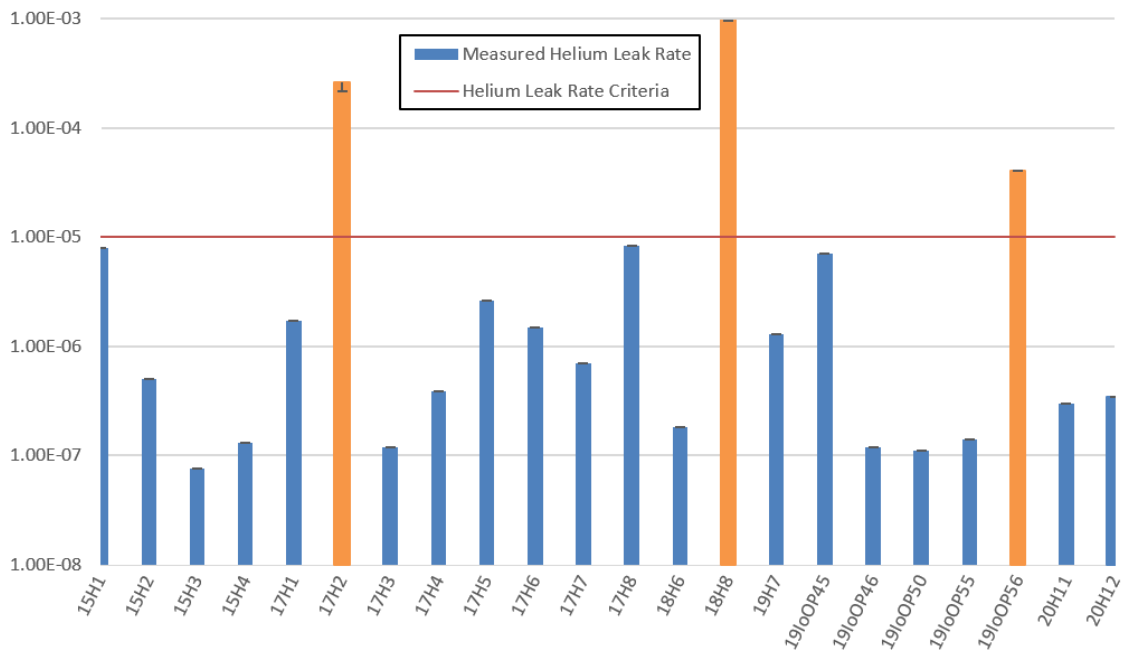


Figure 4-4 All available helium leakage rates measured for Hagan container from FY15 to FY20. The red line shows the failure criteria. One container failed each in FY17, FY18 and FY19 (orange bars). Values on y-axis are in atmcc/sec.

4.1.1.2 O-ring Hardness Tests

The two Hagan O-rings tested in FY20 had hardness values of 74.1 and 73.4 durometer units, respectively. The durometer results for the Hagan storage container are shown in Figure 4-5 for all Hagan containers measured between FY15 and FY20. The O-ring from container 18H8 exceeded the specification limit of 80.0 durometer units. The O-ring hardness for FY15 through FY20 containers ranged from 73.4 to 80.5 and had an average of 78.0 durometer units. The population of 20 O-rings used as a baseline in the lifetime extension studies have a hardness of 76.8 ± 6.07 durometer units, with a maximum of 78.6 and a minimum of 73.9 durometer units. These baseline O-ring measurements were performed on unused Hagan O-rings that had been stored in plastic bags.

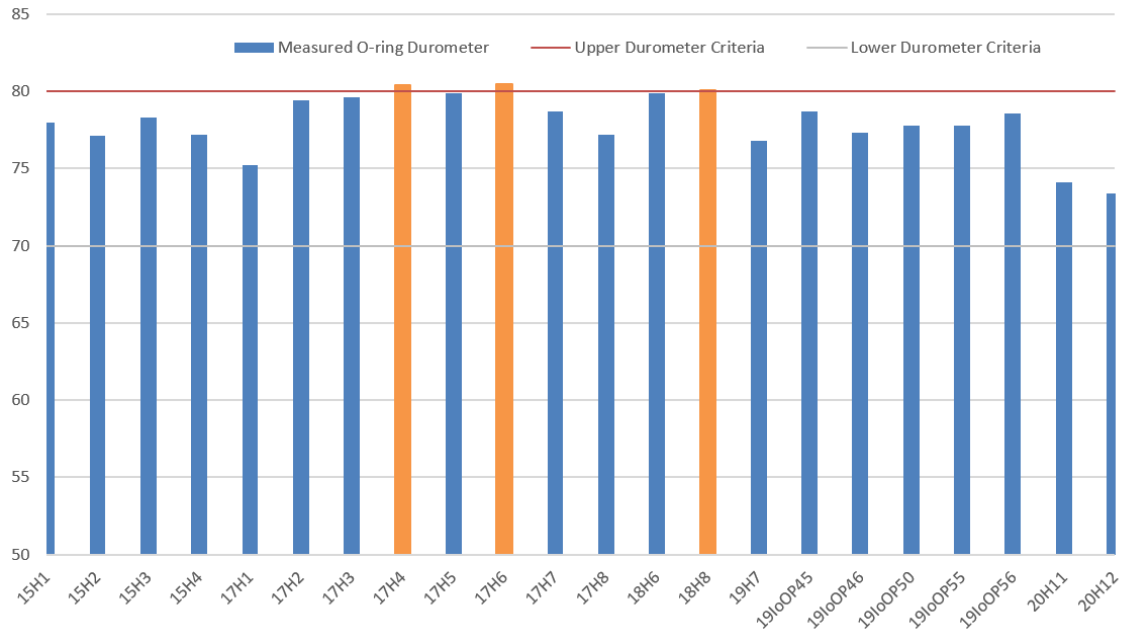


Figure 4-5 All available durometer measurements for Hagan containers from FY15 to FY20. The red and silver lines represent the upper and lower bounds for the hardness, respectively. Two O-rings from FY17 and one O-ring from FY18 failed the hardness criteria (orange bars). The O-ring durometer values on the y-axis are Shore-M hardness values.

4.1.2 Filter Tests

4.1.2.1 Particle Penetration

The aerosol data are reported as a percent penetration, also known as the percent leakage. Two Hagan containers were particle penetration tested in FY20 and compared with the results from FY15, 16, 17, 18 and 19 in Figure 4-6. The set of particle penetration measurements obtained between FY15 and FY20 is narrowly distributed and is at least a factor of 2 lower than the requirement. No Hagan filters have failed the particle penetration test.

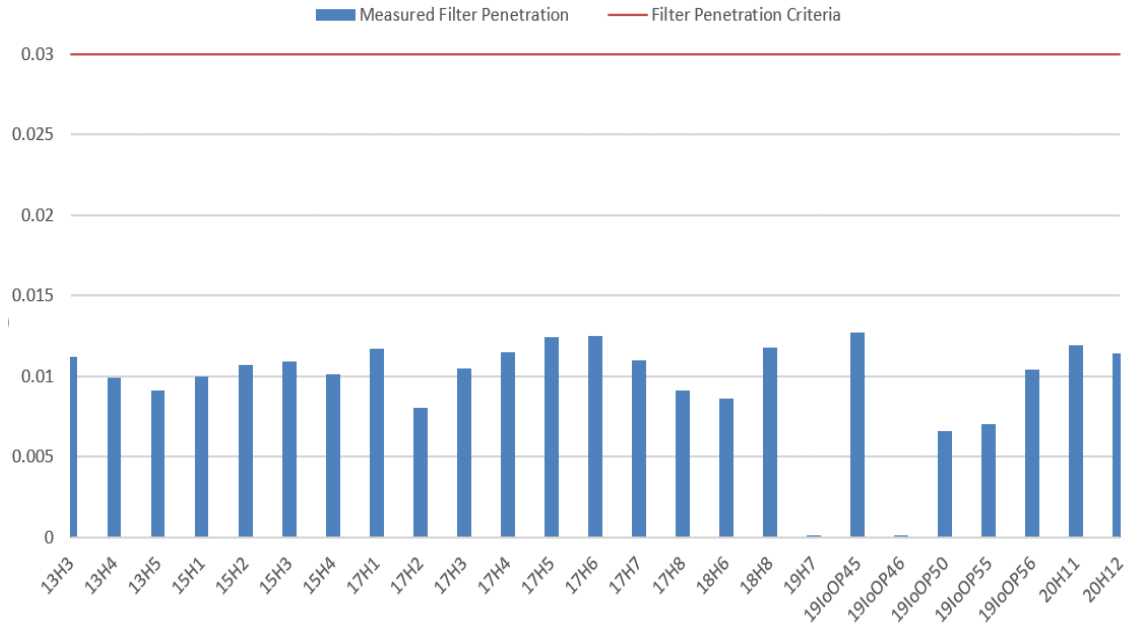


Figure 4-6. All available filter particle penetration measurements for Hagan containers measured from FY15 to FY20. The red line represents the upper bound for filter penetration. Values on y-axis are the filter efficiency.

4.1.2.2 Pressure Drop

Two Hagan containers were pressure drop tested in FY20 and compared with the results from FY15,16,17,18 and 19 in Figure 4-7. The average pressure drop across Hagan filters for the data collected between FY15 and FY19 is 0.704 in. W.C.

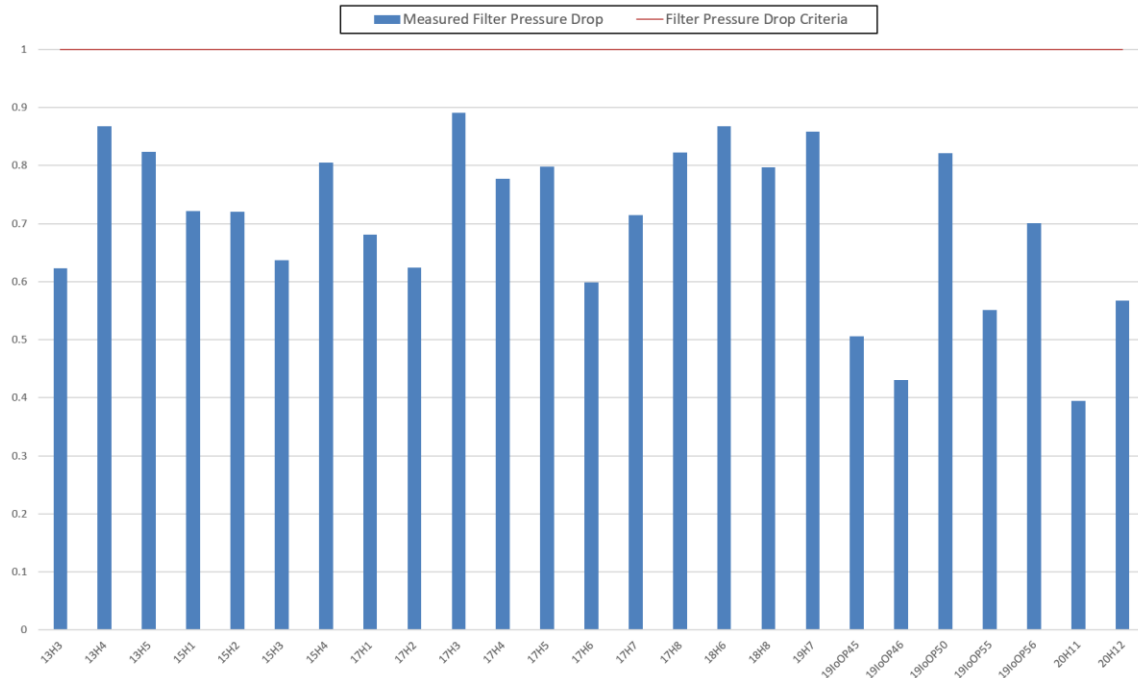


Figure 4-7 All available filter pressure drop measurements for Hagan containers measured from FY15 to FY20. The red line represents the upper bound for filter pressure drop. Values on y-axis are pressure drop in units of inches W.C.

4.1.3 Corrosion

Corrosion was found on one of the three Hagan containers surveilled this year. The amount of the corrosion was minor in appearance and seemed to be evenly distributed on the Hagan's inner surfaces.

The container management team formed a corrosion working group, bringing together people from the 3013 studies and SAVY 4000/Hagan surveillance team members to further investigate the corrosion effects and guide the container surveillance. Surveillance in FY21 will continue to target containers with a high likelihood for corrosion. These containers include other containers with MSE salts with a high wattage to volume ratio or bag degradation factor [10]. Additionally, the future surveillance will target other material forms and material types not yet included in the surveillance program to investigate corrosion in these containers.

4.2 SAVY 4000

The results for the SAVY 4000 storage containers are summarized in Table 8. All O-rings passed a helium leakage test and durometer measurements. The first ever failure of filter performance was observed in FY20 in container 20S8(108). Not all SAVY 4000 storage containers were returned to service in FY20. Three containers in total were removed from storage service, one was due to damage caused by a drop as it was being taken down to the area in which surveillance is performed and the other was due to failing filter performance tests and the third was removed due to it being introduced into

the glovebox. Seven random sample SAVYs were surveilled in FY20 and they are denoted with a numeric value between parentheses.

Random sample 20S9(203) was surveilled inside of the glovebox and therefor does not have measurements for helium leak rate, filter particle penetration, filter pressure drop and durometer values listed in the following sections.

Table 8 Surveillance test results for SAVY 4000 storage containers.

ID (Random ID)	Container Serial No. and Size	Container Visual Inspection	Corrosion Ranking	O-Ring Visual Inspection	Material Name and IDC	Sample Power (W)	Package Age (y)	Filter Particle Penetration (%) ± 0.0002	Filter Pressure Drop (in W.C) ± 0.02	Helium Leakage Rate ($\frac{atm-cc}{s}$)	O-ring Durometer (Shore M) ± 2.15
20S6 (32)	021205013 5 Quart	Some discoloration and smudging in the internal body of the container body	1	Some dust and lint on the O-ring but it wipes away still ok.	HNN5216CF M74M	5.6	8.44	0.0001	0.56	8.5E-08	56.7
20S7 (75)	041205019 5 Quart	Tape or bag residue on internal body wall still good.	0	Some dust still good wipes away	PMP71205B M441	1.41	7.66	0	0.491	1.4E-07	57.2
20S8 (108)	041205009 5 Quart	Tape residue on the inner bottom of container	0	Nothing of note	1153-3A C217	0	7.5	0.07	0.421	1.3E-07	57.6
20S9 (119)	091205175 5 Quart	There is general corrosion level 2 in the inside of the body and lid	2	Small inclusions from manufacturing still passes	XBSOX153 R422	2.84	7.47	0.0003	0.524	8.5E-08	55.9
20S9 (132)	121101026 1 Quart	Some discoloration in the body, maybe some small corrosion starting in the bottom of the body.	1	Nothing of note	SCP-1741A C217	0.98	7.44	0.0003	0.462	1.5E-07	56.4
20S9 (174)	041208067 8 Quart	N/A	0	Some dust on O-ring wipes away.	SLT1304 R422	1.84	7.39	0.0003	0.409	8.6E-08	56.3

ID (Random ID)	Container Serial No. and Size	Container Visual Inspection	Corrosion Ranking	O-Ring Visual Inspection	Material Name and IDC	Sample Power (W)	Package Age (y)	Filter Particle Penetration (%) ± 0.0002	Filter Pressure Drop (in W.C) ± 0.02	Helium Leakage Rate $(\frac{atm-cc}{s})$	O-ring Durometer (Shore M) ± 2.15
20S9 (203)	041208030 8 Quart	N/A	0	Some dust and lint was found wipes away, still good.	R700121 M441	11.18	6.04	N/A	N/A	N/A	N/A
20S10	081305233 5 Quart	Small amount of discoloration from the bag out bag on inside wall of container body still good	0	Small dust particles wipes away ok	LZB225-RM640 C217	6.04	3.33	0	0.509	9.6E-08	56.8
20S12	081305262 5 Quart	Some discoloration from bag out bag inside the body side good	0	Dust wipes away hair wipes away some inclusion in the o-ring still ok	BMB21OXC1 C217	5.98	3.31	0.0002	0.602	9.5E-08	57.1
20S13	081305181 5 Quart	Discoloration inside the probably from the presence of a heat source the container still passes	1	Nothing of note	CASKL2143 C212	5.94	3.31	0	0.478	7.8E-08	56.8
20S14	021608089B 021608129L 8 Quart	Nothing of note	0	Some small inclusions from the manufacture O-ring is still good to go	LZB223-RS-183 C217	5.73	3.31	0.0003	0.58	7.2E-08	56.8

ID (Random ID)	Container Serial No. and Size	Container Visual Inspection	Corrosion Ranking	O-Ring Visual Inspection	Material Name and IDC	Sample Power (W)	Package Age (y)	Filter Particle Penetration (%) ± 0.0002	Filter Pressure Drop (in W.C) ± 0.02	Helium Leakage Rate $(\frac{atm-cc}{s})$	O-ring Durometer (Shore M) ± 2.15
20S15	111308078 8 Quart	Nothing of note	0	Dust wipes away hair wipes away the o-ring still ok	CXPROD192 C217	2.35	2.42	0.0004	0.47	1.5E-07	58
20S16	071201046 1 Quart	Nothing of note	0	Dust wipes away hair wipes away some inclusion in the o-ring still ok	UAS-2634-K88, UAS-2647- K88,UAS-2909- H89,UAS-3020- B90,UAS-2732- E89 C21E	16.9	4.39	0.0001	0.484	6.2E-08	56.5

4.2.1 Visual Inspections

Visual inspections of each container revealed SAVY 4000 containers with corrosion issues. Photographs of these containers were taken and the containers are held if further analysis is determined to be necessary.

4.2.1.1 SAVY 4000 Container, Surveillance, Sample 20S16, SN 031105052, UAS-2634-K88, UAS-2647-K88, UAS-2909-H89, UAS-3020-B90, UAS-2732-E89, MT83, 36 g Pu, Stringer, 16.9 W, 3.7 years

Container 20S16 was packaged with MT83 items. The material was inside of welded sealed source containers. The five small containers (with the pelleted samples inside), were placed directly inside of a 1 Qt. SAVY and cushioned by steel wool. Photographs were taken on the inner packing configuration are shown in Figure 4-8. The outer and inner condition of the SAVY container were relatively pristine the sealing surfaces and functional closure mechanism of the container were not impeded. This SAVY was selected due to an issue outlined in Los Alamos National Laboratory Lessons Learned for Fiscal Year 2018 [11] where an issue with the use of bar stock as the lid material caused small failing leaks. In an extent of condition analysis, this container was tagged as having a higher than typical helium leak rate from the vendor, NFT Inc. In the surveillance of this container, the leak rate was in the expected range and no visual defects were observed.

Table 9. Unpacking Data for Sample 20S16

Surveillance sample number	20S16
Person performing the repack	Christopher Roybal
Date of Unloading	9/12/19
SAVY 4000 or Hagan Serial #'s:	Body: 071201046
	Lid: 071201046
Overall Package Weight Before Unloading:	Not noted
Outer Container Condition:	Good
Pewter Outer Shielding present?	No
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	Not Noted
O-ring installed?	Yes (photo)
Pewter Internal shielding present?	No
Condition of bag out bag?	No Bag-out bag, items are sealed samples surrounded by steel wool.
Any liquid observed inside/outside the bag-out-bag?	No bag-out bag
Type of inner container:	Key Ring Size Sealed Pellets
Item content verification:	Not noted
Condition of inner container?	Not noted
Will bag-out bag be replaced before re-pack?	Not Noted
Will inner container be replaced before re-pack?	Pellets will be repacked into a 3Qt SAVY, SN 021808013 B/L
Overall package weight after repack:	Not Noted
Comments:	6 mrem/hr Alpha-Beta-Gamma-on contact, 8 mrem/hr Neutron on contact



Figure 4-8 (A) The O-Ring in place on the lid. (B) The internal packing configuration of 20S16.

4.2.1.2 SAVY 4000 Container, Surveillance, Sample 20S15, SN 111308078, CXPROD19, MT52, 1020.60g, C217, Impure Oxide / No Major Contaminant, 2.35 W, 3.75 years

Container 20S15 was a relatively pristine unit loaded with Pu 240 oxide, no photographs were collected as a camera could not be accessed during this surveillance activity.

Table 10. Unpacking Data for Sample 20S15

Surveillance sample number	20S15
Person performing the repack	Doug David Ditsworth
Date of Unloading	6/20/2019
SAVY 4000 or Hagan Serial #'s:	Body: 111308078
	Lid: 111308078
Overall Package Weight Before Unloading:	Not measured
Outer Container Condition:	Good
Pewter Outer Shielding present?	No
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Like new
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Paint Can
Item content verification:	CXPROD192, MT 52, NM(g) 893.0
Condition of inner container?	Not Noted
Will bag-out bag be replaced before re-pack?	Not Noted
Will inner container be replaced before re-pack?	Not Noted
Overall package weight after repack:	Not measured
Comments:	7 mrem/hr Alpha-Beta-Gamma-on contact, 2 mrem/hr Neutron on contact

4.2.1.3 SAVY 4000 Container, Surveillance, Sample 20S10, SN 081305233, LZB225-RM640, MT52, 2295.33g, C217, Impure Oxide / No Major Contaminant, 16.04 W, 3.2 years

Container 20S10 was packed with MT52 in the form of impure dioxide. The material was in a stainless steel taped slip lid, which was had two bags around it. The inside of the SAVY body did have some tape residue on it. Generally, the container looked to be in good condition.

Table 11. Unpacking Data for Sample 20S10

Surveillance sample number	20S10
Person performing the repack	Edward Romero
Date of Unloading	1/27/20
SAVY 4000 or Hagan Serial #'s:	Body:081305233
	Lid: 081305233
Overall Package Weight Before Unloading:	8531.7 g
Outer Container Condition:	Good
Pewter Outer Shielding present?	Yes
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	Not Noted
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Good, double bag-out bag
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Taped slip lid stainless steel
Item content verification:	LZB225-RM640
Condition of inner container?	Good,
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	N/A

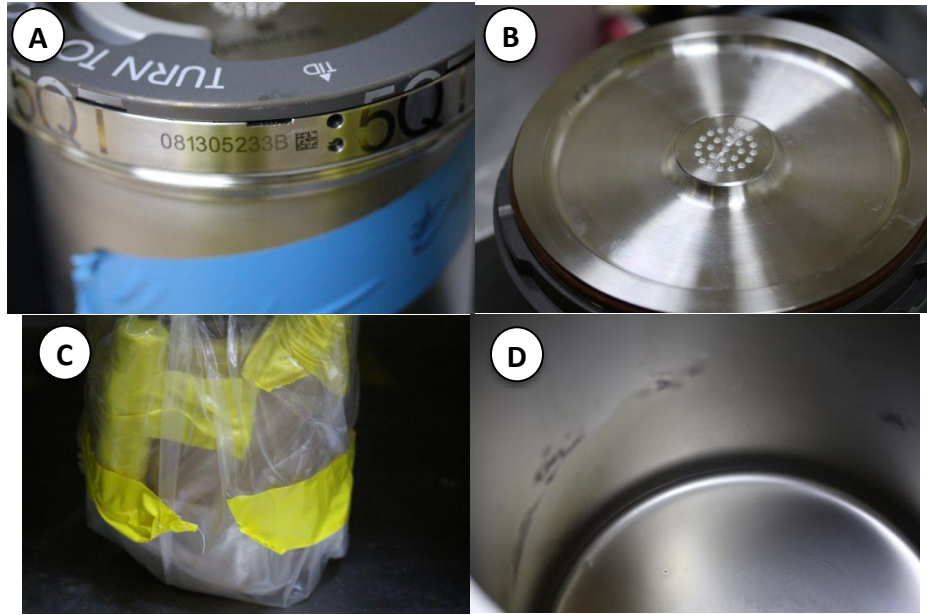


Figure 4-9 Visual inspection results of 20S10 during unpacking. (A) Outside serial number verification of 20S10. (B) Internal face of the lid the filter media appears intact and clean. (C) Internal slip lid placed in double bag-out bags. (D) tape residue on the inside surfaces of the SAVY-4000.

4.2.1.4 SAVY 4000 Container, Surveillance, Sample 20S12, SN 081305262, BMB21OXC1, MT52, 2270.50g, C217, Pu Oxide / No Major Contaminant, 5.98 W, 3.18 years

Container 20S12 was packaged with MT52 in the form of impure oxide. The material was packaged inside of a stainless steel taped slip lid. The out surfaces of the SAVY was in good condition. The inner surfaces of the SAVY had tape residue and tape stuck to it. The bag was in good condition with slight discoloration.

Table 12. Unpacking Data for Sample 20S12

Surveillance sample number	20S12
Person performing the repack	Edward Romero
Date of Unloading	6/20/2019
SAVY 4000 or Hagan Serial #'s:	Body: 081305262
	Lid: 081305262
Overall Package Weight Before Unloading:	8488.7 g
Outer Container Condition:	Good
Pewter Outer Shielding present?	Yes
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Good, some discoloration
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Taped Slip Lid Stainless Steel
Item content verification:	BMB21OXC1
Condition of inner container?	Good
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	N/A



Figure 4-10 Visual inspection results of 20S12 during unpacking. (A) Outer container serial number verification. (B) Internal body with visible tape residue/tape on container walls. (C) Inner package bag-out bag.

4.2.1.5 SAVY 4000 Container, Surveillance, Sample 20S13, SN 081305181 CASKL2143, MT52, 2256.42g, C212, Pu Ooxide; Multiple Alloys or Contaminants, 5.94 W, 3.17 years

Container 20S13 was packed with MT52 in the form of multiple alloys or contaminants. No photos were taken of the inner surfaces, but light corrosion was observed during the container integrity inspection. The corrosion rating for this container was a 1-isolated general corrosion.

Table 13. Unpacking Data for Sample 20S13

Surveillance sample number	20S13
Person performing the repack	Edward Romero
Date of Unloading	1/28/20
SAVY 4000 or Hagan Serial #'s:	Body: 081305181
	Lid: 081305181
Overall Package Weight Before Unloading:	8381.6 g
Outer Container Condition:	Good
Pewter Outer Shielding present?	Yes
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	Yes
Condition of bag out bag?	Good
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Taped Slip Lid Stainless Steel
Item content verification:	CASKL2143
Condition of inner container?	Good
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	46.0 mrem/hr Alpha-Beta-Gamma-on contact, 19.0 mrem/hr Neutron on contact

**4.2.1.6 SAVY 4000 Container, Surveillance, Sample 20S14, SN 021608089B
021608129L, LZB223-RS-183, MT52, 2177.50g, C217, Pu 240, Impure Oxide/No
Major Contaminant, 5.73 W, 3.2 years**

Container 20S14 was packed with Pu oxide. The material was packaged inside of a stainless steel slip lid container. The container and bag out bag was in good condition. Low level contamination was found by the repack team and was decontaminated for surveillance.

Table 14. Unpacking Data for Sample 20S14

Surveillance sample number	20S14
Person performing the repack	Edward Romero
Date of Unloading	1/28/20
SAVY 4000 or Hagan Serial #'s:	Body: 021608089 B
	Lid: 021608126 L
Overall Package Weight Before Unloading:	9667.0 g
Outer Container Condition:	Good
Pewter Outer Shielding present?	Yes
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Container was mildly contaminated (De-coned by Ron Chavez & company)
Any liquid observed inside/outside the bag-out-bag?	No
Type of inner container:	Taped Stainless Steel slip Lid
Item content verification:	Not Noted
Condition of inner container?	Good
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	35.0 mrem/hr Alpha-Beta-Gamma-on contact, 15.0 mrem/hr Neutron on contact

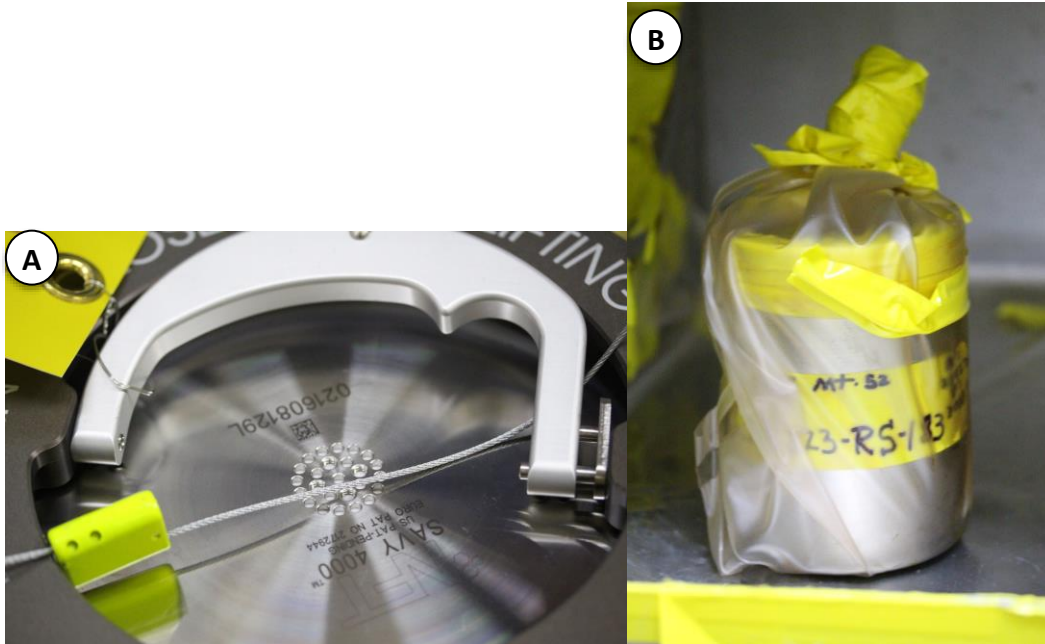


Figure 4-11 Visual inspection results of 20S14 during unpacking. (A) The filter media and diffusion holes are pristine. (B) Inner package appears intact.

4.2.1.7 SAVY 4000 Container, Surveillance, Sample 20S7(75), SN 041205019, PMP71205B, MT52, 535.29g, M44, Pu 240, Unalloyed Metal, 1.14 W, 7.4 years

Container 20S7(75) was packaged with MT52 in the form of unalloyed metal. The container appears to have a small amount of bag or tape residue on the inner surface. This container management team was not present for the unpack. The container was released to the team several months after the unpack occurred.

Table 15. Unpacking Data for Sample 20S7(75)

Surveillance sample number	20S7(75)
Person performing the repack	Dung Vu
Date of Unloading	?
SAVY 4000 or Hagan Serial #'s:	Body: 041205019
	Lid: 041205019
Overall Package Weight Before Unloading:	535.29g
Outer Container Condition:	Good
Pewter Outer Shielding present?	Not noted
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes (Photo)
Pewter Internal shielding present?	Not Noted
Condition of bag out bag?	Not Noted
Any liquid observed inside/outside the bag-out-bag?	Not Noted
Type of inner container:	Not Noted
Item content verification:	PMP71205B
Condition of inner container?	Not Noted
Will bag-out bag be replaced before re-pack?	Not Noted
Will inner container be replaced before re-pack?	Not Noted
Overall package weight after repack:	Not Noted
Comments:	Container was replace with 081305190 B/L



Figure 4-12 Visual inspection results of 20S7(75) during unpacking. (A) Filter media appears clean and serial number verification. (B) Some tape residue on the internal wall of the body of the container.

4.2.1.8 SAVY 4000 Container, Surveillance, Sample 20S8(108), SN 041205009, 11530-3A, MT38, 2070.79g, C21, Pu Oxide, 2.8 W, 6.4 years

Container 20S8(108) was packaged with enriched uranium dioxide. This container failed the filter efficiency testing and subsequently the water penetration test. This is the first SAVY-4000 container to fail these tests. Upon the conclusion of the failed filter efficiency test, the filter diffusion holes were visually inspected and an area of concern was identified (Figure 4-13). The container was declared “in-operable” and permanently segregated and removed from PF-4. NCR-2020-208 was generated because of this condition and further testing is planned.

Table 16. Unpacking Data for Sample 20S8(108)

Surveillance sample number	20S8(108)
Person performing the repack	Todd P. Martinez
Date of Unloading	8/31/20
SAVY 4000 or Hagan Serial #'s:	Body: 041205009
	Lid: 041205009
Overall Package Weight Before Unloading:	6612.0 g
Outer Container Condition:	Good
Pewter Outer Shielding present?	Yes
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Brittle, stuck to the inner container some corrosion on the inner container.
Any liquid observed inside/outside the bag-out-bag?	Small residue inside
Type of inner container:	Taped slip-lid stainless steel
Item content verification:	Not Noted
Condition of inner container?	Small amounts of corrosion
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	N/A

20S8(108) was being filter performance tested when the operator recognized that the test would not conclude. The lid of 20S8(108) was then removed from the filter test system (FTS) and the filter was inspected. Upon closer inspection, damage was observed (Figure 4-13). A second filter test was attempted in hopes that the FTS would be able to complete a test and generate a report. The FTS was allowed to run for ~45 minutes but did not conclude so the operator took the average downstream concentration reading from the photometer and calculated a percent penetration of 0.07%. The lid from 20S8(108) was also water penetration tested and water was observed after ~1.5 minutes with a water column of 12 inches on the exterior surface. An NCR was generated as soon the container was determined to not meet the surveillance test criteria. The container was brought out of PF-4 so that laser confocal microscopy (LCM) images could be collected to determine the extent of the damage. The LCM images suggested that the damage penetrated ~3.5mm or 65% into the filter (Figure 4-15). The filter media was then removed from the SAVY lid to determine how deep the damage penetrated. It was determined that the damage went into the third and final layer of Fiberfrax®, but did not appear to go all the

way through this last layer. Analysis is planned to investigate what type of residue is surrounding the damage to attempt to find what caused the damage.



Figure 4-13 Observed damage on top of filter membrane.



Figure 4-14 Optical images from LCM analysis of damaged filter area.

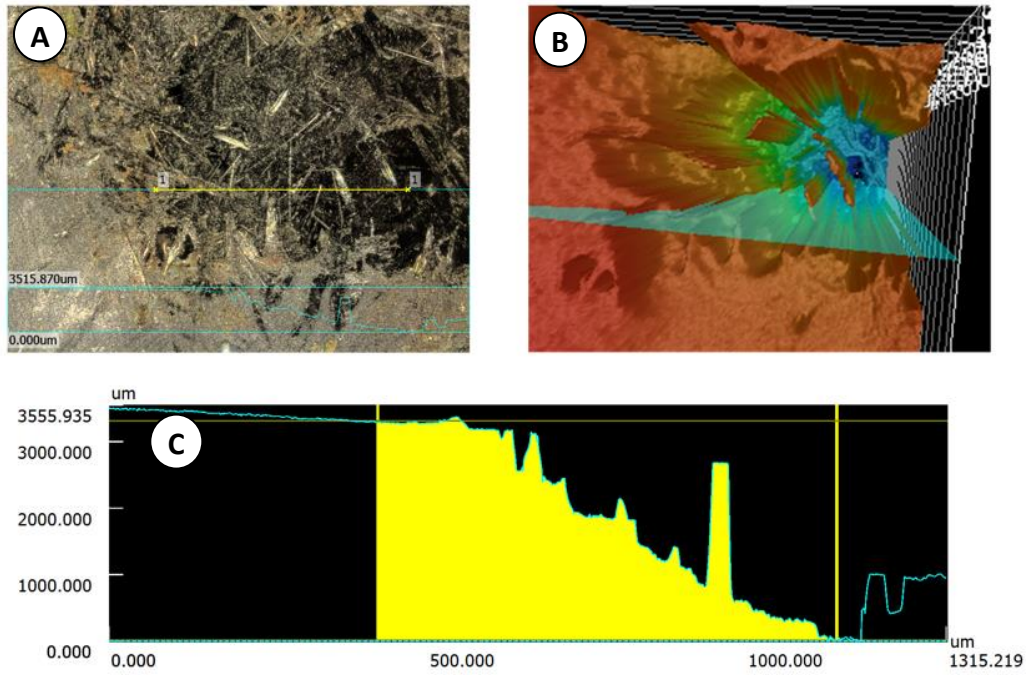


Figure 4-15 LCM data showing the depth (3.2mm) of the damage in the filter membrane and media. (A) Optical image of area scanned by LCM. (B) LCM data shown as a heat map. (C) LCM data as a profile along a line.



Figure 4-16 Photograph of all of the filter layers. Layer one in the hydrophobic membrane. Layer two through four are the Fiberfrax® filter material. Damage can be seen on all layers.

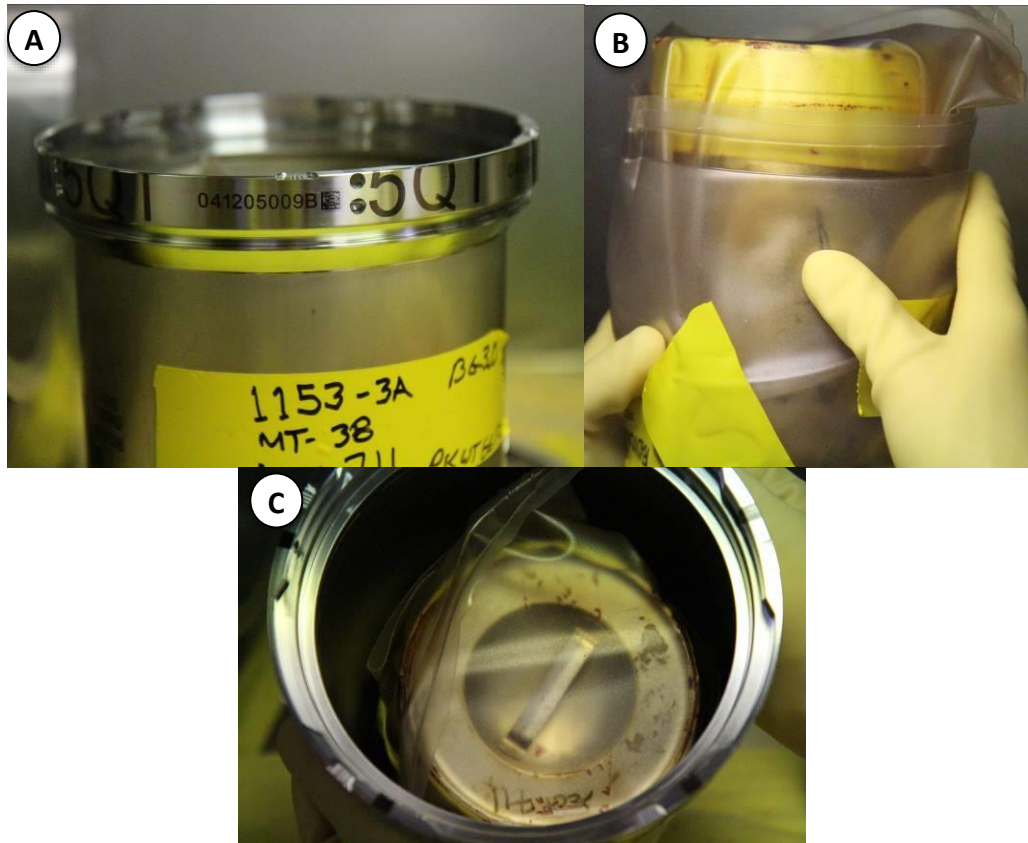


Figure 4-17 Visual inspection of 20S8(108). (A) Serial number verification. (B) Good condition of bag out bag. (C) Evidence of corrosion on the inner stainless steel slip lid container.

4.2.1.9 SAVY 4000 Container, Surveillance, Sample 20S6(32), SN 021205013, HNN5216CF, MT52 2085g+MT82 40.0g, M74, METAL; Alloyed metal, Pu/Np 237, 5.59 W, 7.6 years

Container 20S6(32) was loaded with an Alloyed Metal of Pu and Np, the material was shielded inside of a pewter slip lid inner container. The pewter slip showed signs of general corrosion throughout. Upon visual inspection the O-ring appeared to have a slight indentation, resulting in a new O-ring being installed. During the container visual inspection slight discoloration was observed but was able to be whipped clean. The corrosion ranking for 20S6(32) was a 1-isolated general corrosion.

Table 17. Unpacking Data for Sample 20S6(32)

Surveillance sample number	20S6(32)
Person performing the repack	Benjamin Charles Hollowell
Date of Unloading	8/31/20
SAVY 4000 or Hagan Serial #'s:	Body: 021205013
	Lid: 02105013
Overall Package Weight Before Unloading:	Not Noted
Outer Container Condition:	Good
Pewter Outer Shielding present?	Yes at the time of original packaging to be "high rad"
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes, upon visual inspection a defect was found (Photo) and O-ring was replaced with O-ring with PO: 335733 Batch/ Lot # 0081003713 Cure Date 2Q13
Pewter Internal shielding present?	No
Condition of bag out bag?	Good
Any liquid observed inside/outside the bag-out-bag?	Pliable yellow/brown bag
Type of inner container:	Taped slip-lid pewter
Item content verification:	HNN5216CF
Condition of inner container?	Good
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	12.0 mrem/hr Alpha-Beta-Gamma-on contact



Figure 4-18 Visual inspection results of 20S6(32) during unpacking. General corrosion is visible on the walls of the pewter inner shielding.

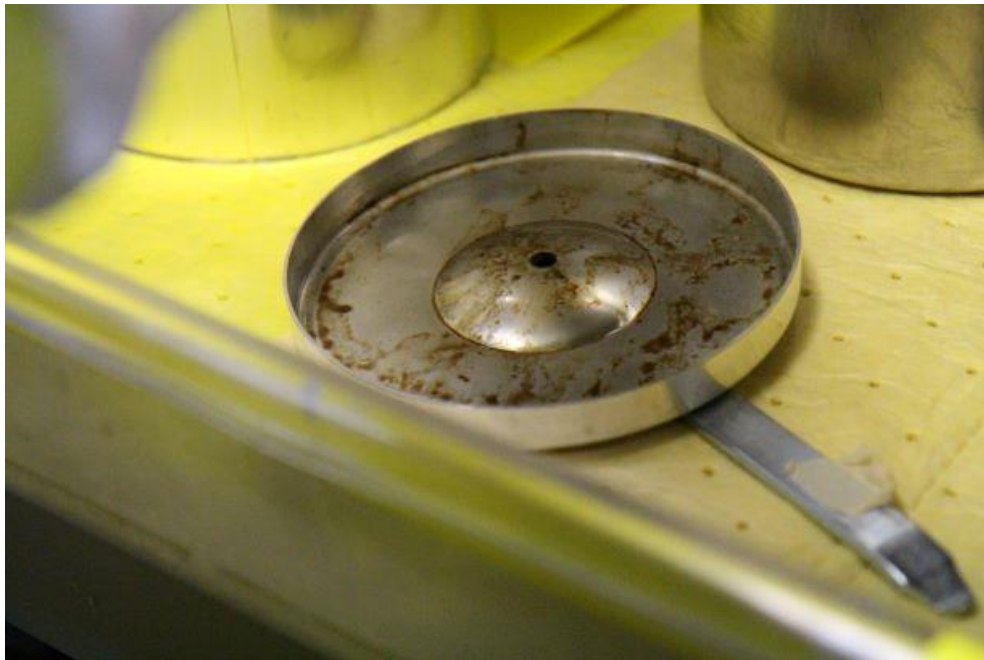


Figure 4-19 Visual inspection results of 20S6(32) during unpacking. Corrosion on underside of lid of the pewter shielding inner container.

4.2.1.10 SAVY 4000 Container, Surveillance, Sample 20S9(174), SN 041208067, SLT1304, MT52, 698.61g, R42, PROCESS RESIDUE; DOR Salt, 1.84 W, 6.5 years

Container 20S9(174) was packaged with a Process Residue DOR salt. The inner container was a taped slip lid and appeared to be in good condition. The bag-out bag was discolored and some residues were seen inside of the SAVY.

Table 18. Unpacking Data for Sample 20S9(174)

Surveillance sample number	20S9(174)
Person performing the repack	Silas Giovanni Romero
Date of Unloading	8/31/20
SAVY 4000 or Hagan Serial #'s:	Body: 041208067
	Lid: 041208067
Overall Package Weight Before Unloading:	1229.69 g
Outer Container Condition:	Good
Pewter Outer Shielding present?	No
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Good
Any liquid observed inside/outside the bag-out-bag?	Brown residue bag is beginning to discolor remains flexible slight stuck to slip lid.
Type of inner container:	Stainless steel taped slip lid
Item content verification:	SLT1304
Condition of inner container?	Good
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	N/A



Figure 4-20 Visual inspection results of 20S9(174) during unpacking. Brown plasticizer can be seen inside of the bag-out bag.



Figure 4-21 Visual inspection results of 20S9(174) during unpacking. A small dent was found on the bottom radius of the SAVY body. A small amount of residue can be seen in the bottom of the SAVY.

4.2.1.11 SAVY 4000 Container, Surveillance, Sample 20S9(132), SN 121101026, SCP-1741A, MT52, 371.49g, C21, Dioxide, 0.97 W, 6.6 years

Container 20S9(132) was packaged with Pu in the form of oxide. The inner container was a taped slip lid and appeared to be in good condition. The bag-out bag was discolored and some residues were seen on the inner surfaces of the SAVY. The corrosion ranking for 20S9(132) was a 1-isolated general corrosion.

Table 19. Unpacking Data for Sample 20S9(132)

Surveillance sample number	20S9(132)
Person performing the repack	Carlos Daniel Archuleta
Date of Unloading	8/31/20
SAVY 4000 or Hagan Serial #'s:	Body: 121101026
	Lid: 121101026
Overall Package Weight Before Unloading:	Not Noted
Outer Container Condition:	Good
Pewter Outer Shielding present?	No
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Good
Any liquid observed inside/outside the bag-out-bag?	Bag-out bag was discolored dark brown
Type of inner container:	Stainless Steel Slip lid "small"
Item content verification:	SCP-1741A
Condition of inner container?	Corroded
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	7.0 mrem/hr Alpha-Beta-Gamma-on contact

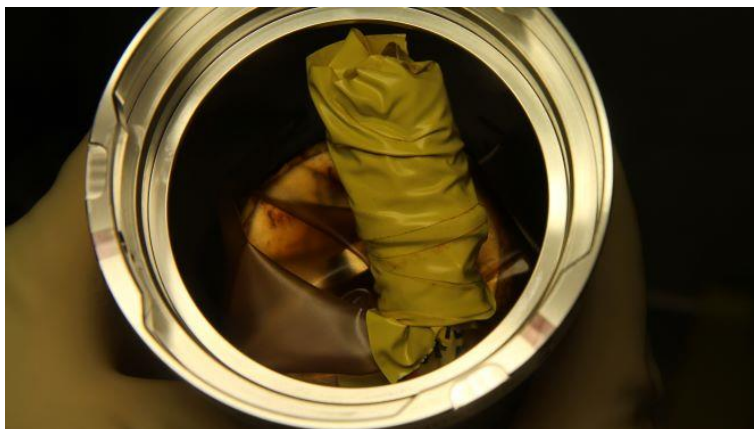


Figure 4-22 Visual inspection results of 20S9(132) during unpacking. The inner packages brown plasticizer can be seen inside of the bag-out bag. Several areas of corrosion on the slip lid can also be seen.



Figure 4-23 Visual inspection results of 20S9(132) during unpacking. General corrosion can be seen around the outside of the slip lid.

4.2.1.12 SAVY 4000 Container, Surveillance, Sample 20S9(119), SN 091205175, XBSOX153, MT52, 1061g, R42, Process Residue DOR Salt, 2.84 W, 6.6 years

Container 20S9(119) was packaged with a DOR salt. The inner container was a taped slip lid and appeared to be in good condition. The bag-out bag was discolored and some residues were seen. 20S9(119) was removed from service due to damage that was sustained during the movement of the empty surveillance container down to the area in which surveillance activities are performed.

Table 20 Unpacking Data for Sample 20S9(119)

Surveillance sample number	20S9(119)
Person performing the repack	Benjamin Charles Hollowell
Date of Unloading	9/1/20
SAVY 4000 or Hagan Serial #'s:	Body: 091205175
	Lid: 091205175
Overall Package Weight Before Unloading:	Not Noted
Outer Container Condition:	Good
Pewter Outer Shielding present?	Yes
Contamination found outside SAVY?	No
Contamination found inside surfaces SAVY?	No
O-ring installed?	Yes
Pewter Internal shielding present?	No
Condition of bag out bag?	Good
Any liquid observed inside/outside the bag-out-bag?	Bag-out bag intact some brown residue inside
Type of inner container:	Stainless steel taped slip lid
Item content verification:	XBSOX153
Condition of inner container?	Corroded, general corrosion and brown residue on inner container
Will bag-out bag be replaced before re-pack?	No
Will inner container be replaced before re-pack?	No
Overall package weight after repack:	Not measured
Comments:	100 mrem/hr on contact of inner container, this container was replaced with 011305008 B/L. This container is being sectioned for LCM images



Figure 4-24 Visual inspection results of 20S9(119) during unpacking. Brown plasticizer can be seen inside of the bag out bag.



Figure 4-25 Visual inspection results of 20S9(119) during unpacking. General corrosion can be seen in the inner surfaces of the SAVY-4000, the most of any container this year.

**4.2.1.13 SAVY 4000 Container, Surveillance, Sample #20S9(203), SN 041208030 ,
R700121 , MT52, 4243.61g, M44, METAL; Unalloyed metal, 11.18 W, 5.2 years**

Container 20S9(203) was packaged with a DOR salt. The inner container taped slip lid appeared in good condition, the bag-out bag was discolored, and some bag residue was observed. This surveillance item was the first SAVY officially put through the in-glovebox surveillance and included a helium leak test and O-ring thickness measurements. This container was introduced for ease of introduction of the item and not due to contamination found on the inner surfaces of the SAVY.

Table 21. Unpacking Data for Sample 20S9(203)

Surveillance sample number	20S9(203)
Person performing the repack	Joshua Narlesky
Date of Unloading	9/30/20
SAVY 4000 or Hagan Serial #'s:	Body: 041208030
	Lid: 041208030
Overall Package Weight Before Unloading:	Not Noted
Outer Container Condition:	Good, small dents on body radius
Pewter Outer Shielding present?	N/A data collected not at time of actual unloading
Contamination found outside SAVY?	N/A
Contamination found inside surfaces SAVY?	N/A
O-ring installed?	Yes
Pewter Internal shielding present?	N/A
Condition of bag out bag?	N/A
Any liquid observed inside/outside the bag-out-bag?	N/A
Type of inner container:	N/A
Item content verification:	N/A
Condition of inner container?	N/A
Will bag-out bag be replaced before re-pack?	N/A
Will inner container be replaced before re-pack?	N/A
Overall package weight after repack:	N/A
Comments:	Tape residue on inside of surface of body. Corrosion level 0.



Figure 4-26 Visual inspection results of 20S9(203) during unpacking. Small dents throughout the bottom radius of container body

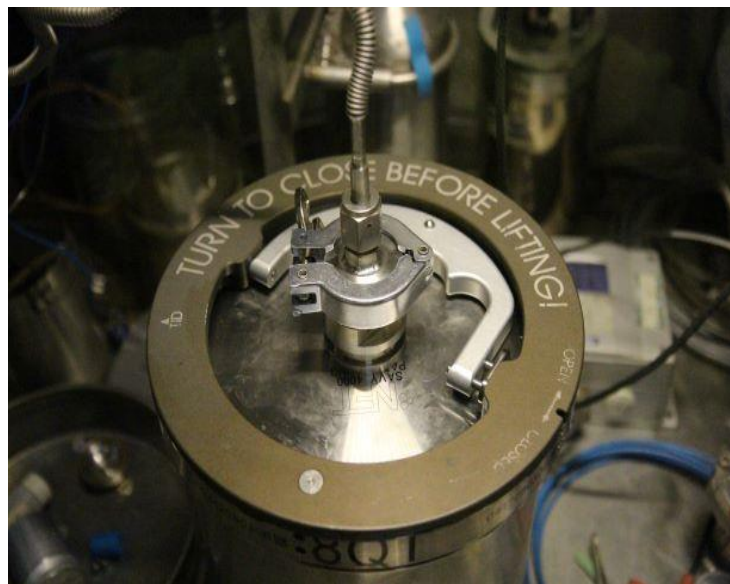


Figure 4-27 Visual inspection results of 20S9(203) during unpacking. Helium Leak testing verified in-glovebox capability.



Figure 4-28 Visual inspection results of 20S9(203) during unpacking. Laser micrometer measurement of O-rings verified in-glovebox capability.

4.2.2 O-ring Tests

4.2.2.1 Visual Inspection of the O-rings

Inspections revealed small amounts of dust and debris on a majority of the O-rings. It is unclear whether this dirt was introduced during the use of the container or during manipulations involved in surveillance. In either case, the dirt was easily removed with an alcohol wipe. Four of the SAVY 4000 O-rings inspected in FY20 had dark inclusions that were thought to have come from the manufacturer. One transfer container O-ring was taken out of service due to a cut. The container with the cut O-ring, after O-ring replacement, was helium leak tested and passed with a leak rate of 2.5×10^{-8} atm cc/s of helium at 75 Torr into vacuum. Due to time constraints associated with repacking the item that was stored in the container with a faulty O-ring, the helium leak rate with the failed O-ring could not be obtained.

4.2.2.2 Container Leakage Rate Tests

The leakage rate results for storage containers with O-rings installed are shown in Figure 4-29. For storage containers in FY20, the measured leakage rate ranged between 6.2×10^{-8} and 1.5×10^{-7} atm cc/s of helium at 75 Torr into vacuum. Every SAVY 4000 in FY20 passed the leakage test, with all measurements being below the failure criterion of 1×10^{-5} atm cc/s.

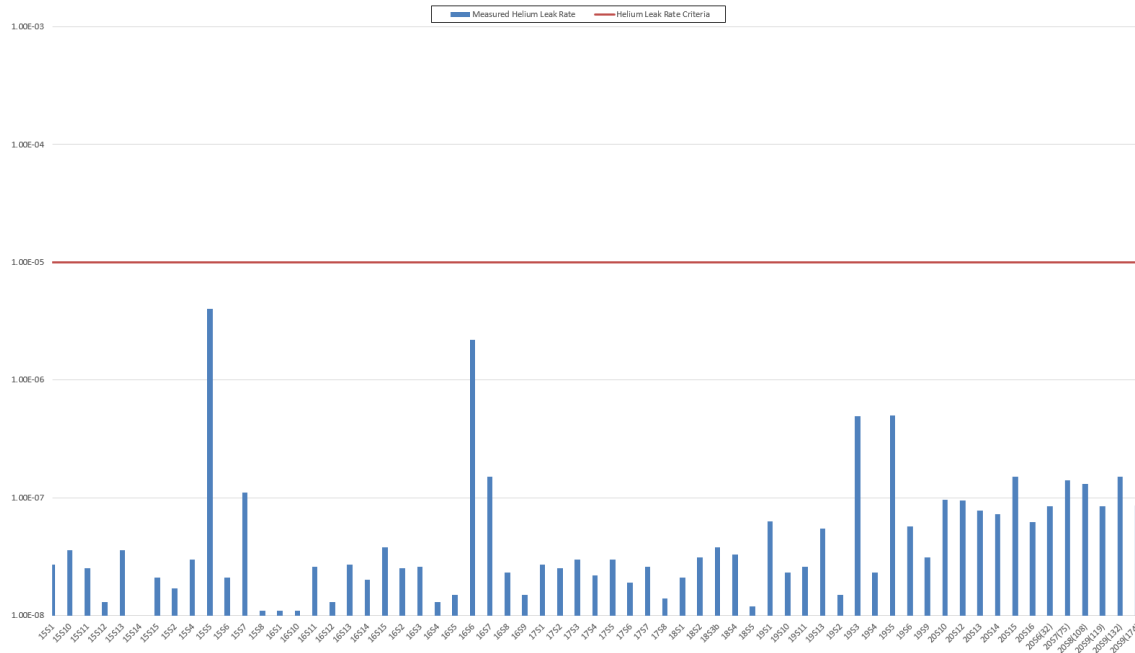


Figure 4-29 Leakage rates for surveillance containers, measured for each container are shown as blue bars with the failure criteria shown with the red line.

Leakage testing is done as a threshold measurement on a logarithmic scale. Only a single point calibration is done to prepare the instrument for use, though it is checked against another, known leakage standard. The calibration value is chosen that is low enough to ensure that the threshold leak—the leakage at which failure of a part is determined—is certain to register on the leakage detector but high enough to be distinguishable from background. The value of the apparent background leakage rate will always decrease during a leakage test, as gas is continuously evacuated from the bell jar, so it is not unusual to see leakage test measurements lower than the background. This means that the leakage test measurement is indistinguishable from the background. These values show measured leakage rates that are indistinguishable from the apparent background, and therefore we have confidence containment has been maintained well below the design release rate. The leakage test measurement does not have a significant correlation with age, estimated dose, or item thermal power.

4.2.2.3 O-ring Hardness Tests

The 12 surveillance O-rings from FY20 were found to have hardness of between 55.9 and 57.6, with an average of 56.8 durometer units. The 14 transfer container O-rings had a hardness between 55.7 and 57.8, with an average of 57.2 durometer units. The 28 O-rings used as a baseline in the lifetime extension studies have a hardness of 57.5 ± 2.62 durometer units, so the storage O-rings are similar in hardness to unused O-rings. The 2.62 unit error is the reproducibility standard deviation as given in ASTM D2240. The measurements are graphed in Error! Reference source not found.. None of the O-rings are especially hard or soft compared with the baseline, and the measurement do not have a significant correlation with age, estimated dose, or item thermal power. All available durometer measurements are plotted in Figure 4-30.

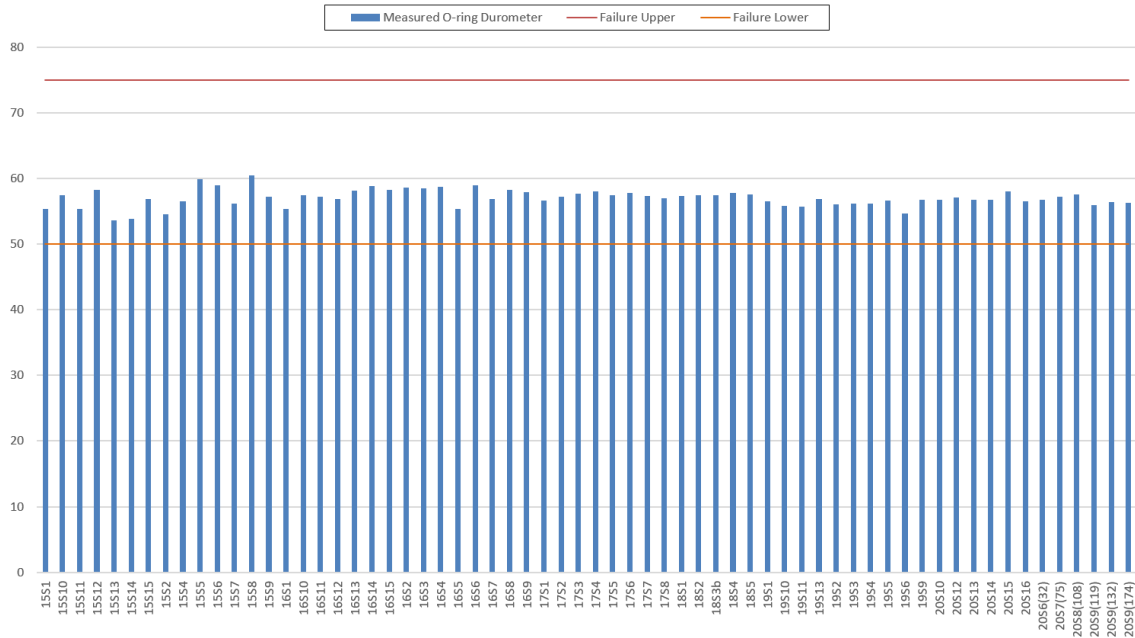


Figure 4-30 Durometer measurements of the surveillance SAVY 4000 O-ring with the red and orange bands showing the upper and lower failure limits, respectively.

4.2.3 Filter Tests

4.2.3.1 Particle Penetration

The aerosol data are reported as a percent penetration, also known as the percent leakage. The set of particle penetration measurements is narrowly distributed and very far from the failure criterion, with the exception of 20S8(108) as graphed in Figure 4-31. A set of baseline particle penetration measurements does exist, but it is not clear how those measurements, taken on a different type of instrument with a different configuration, relate to the measurements taken in PF-4 with our instrument. Although we may not be able to tell how the particle penetration is changing from baseline, we will be able to track how the particle penetration changes relative to containers' peers in the sample population.

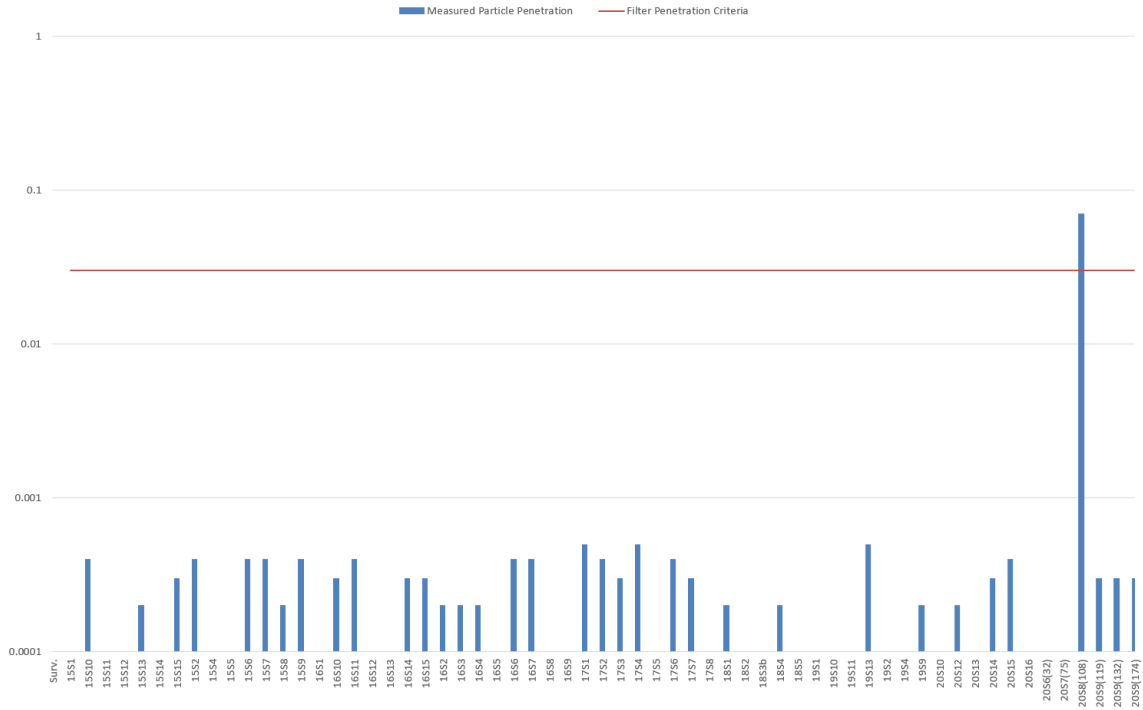
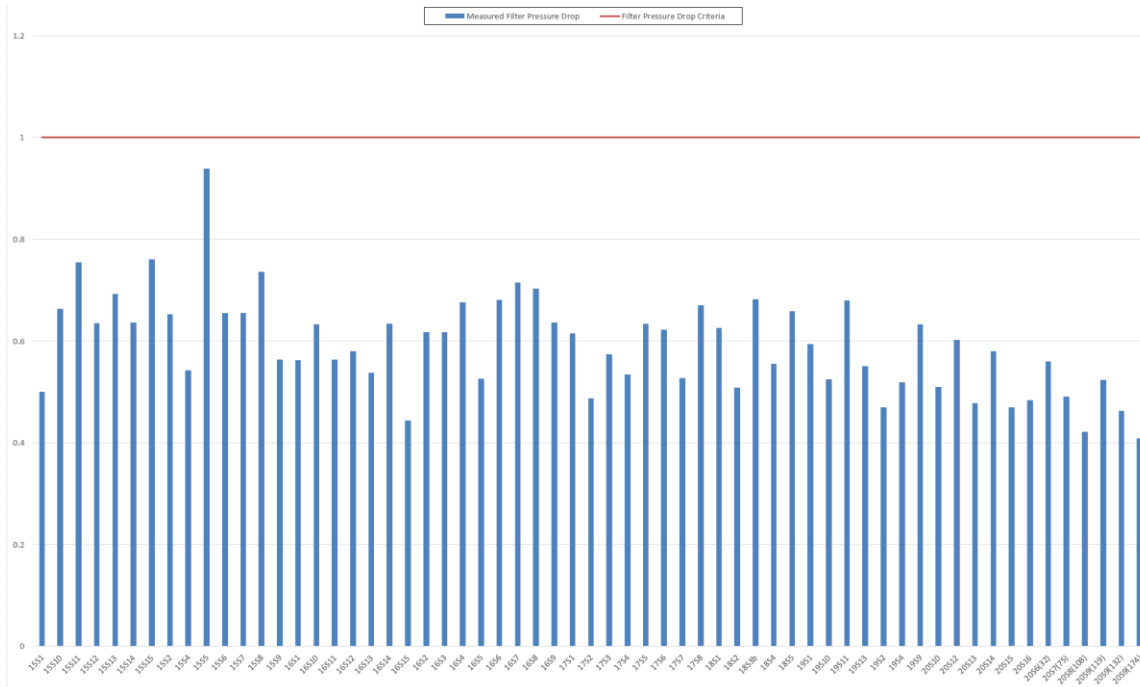


Figure 4-31 Filter particle penetration measurements for SAVY-4000 containers with the red line representing the failure criteria.

4.2.3.2 Pressure Drop

The pressure drop measurements from FY20 have an average of 0.499 in. W.C. ± 0.07 . The results are graphed below in Figure 4-32.



4.3 Trending Analysis

One of the goals of surveillance is to evaluate trends over time for those measurements that have quantitative values, e.g., Helium (He) leak rate, particle penetration, filter pressure drop, durometer (Shore M hardness) and compression set (CS). A trend analysis of these measurements can support O-ring lifetime extension assessments. In addition, a trend analysis can help identify containers whose measurements appear to be outliers when compared to those of the other containers. Outlier containers will be evaluated to determine if they should be re-examined in future surveillances.

4.3.1 Helium Leak Rate

Figure 4-33 **Trend analysis of He leak rate versus SAVY age for containers from 2015-2020** shows He leak rate versus age. The containers denoted with colored circles are the five containers that have been examined at least twice in 2015 through 2020. The black circles are the remainder of the SAVY surveillance containers (38 containers). (One of the SAVY containers, item 20S9 (random ID 203) did not have an official helium leak rate measurement as it was in the glovebox, but it did pass a glovebox leak rate test.) The black horizontal line on the graph is the acceptance limit for He leak rate. To date, there is no trend with time for leak rate. There is one outlier, XBLSC1213 (the highest black point) that was discovered in 2018. This container was corroded and it required cleaning to pass the leak test, however it is well below the acceptance rate. This container will be re-examined again in a future surveillance. XAP6 outer container and ROTRBJ-1C1 were not re-examined in 2020, but will also be re-examined in a future surveillance.

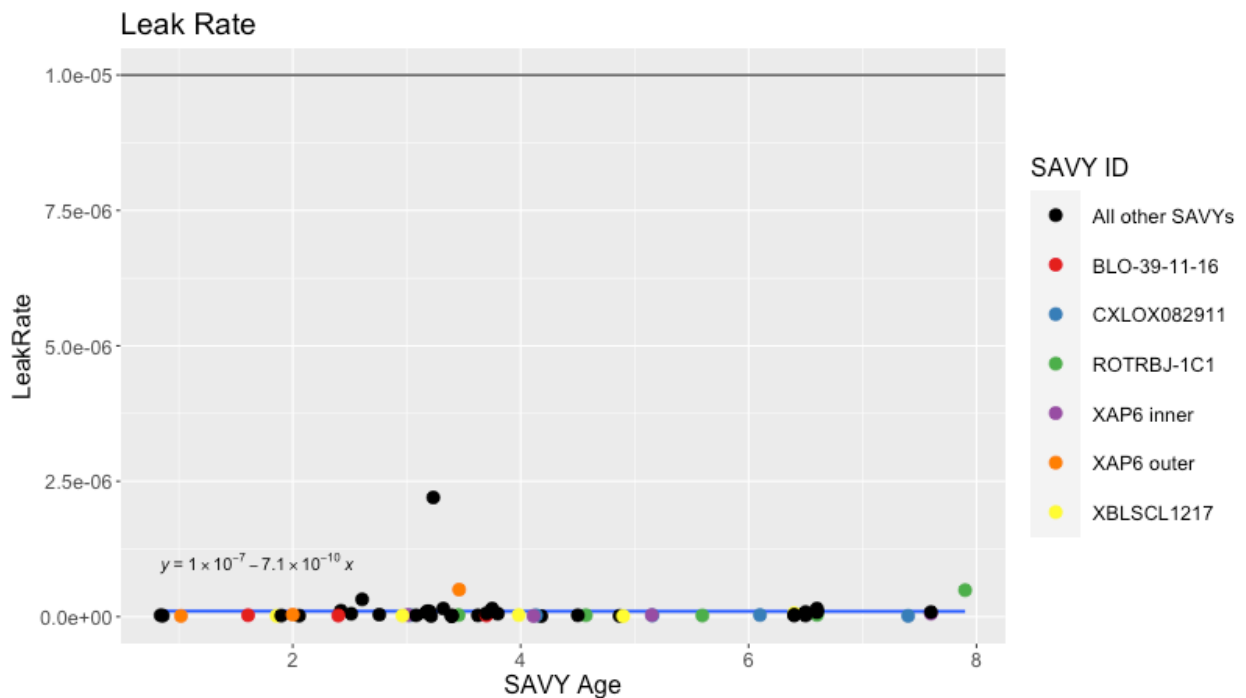


Figure 4-33 Trend analysis of He leak rate versus SAVY age for containers from 2015-2020

4.3.2 O-ring Discussion

There were no significant O-ring issues found in the SAVY 4000 containers this year.

Figure 4-34 shows durometer measurements versus SAVY age. There is a slight downward trend, however there is considerable variability and the containers that have been measured multiple times (colored dots) do not show a trend. The black horizontal lines are the acceptance limits, the blue line is the trend line, and the gray shaded area is the 95% confidence bound for the trend line.

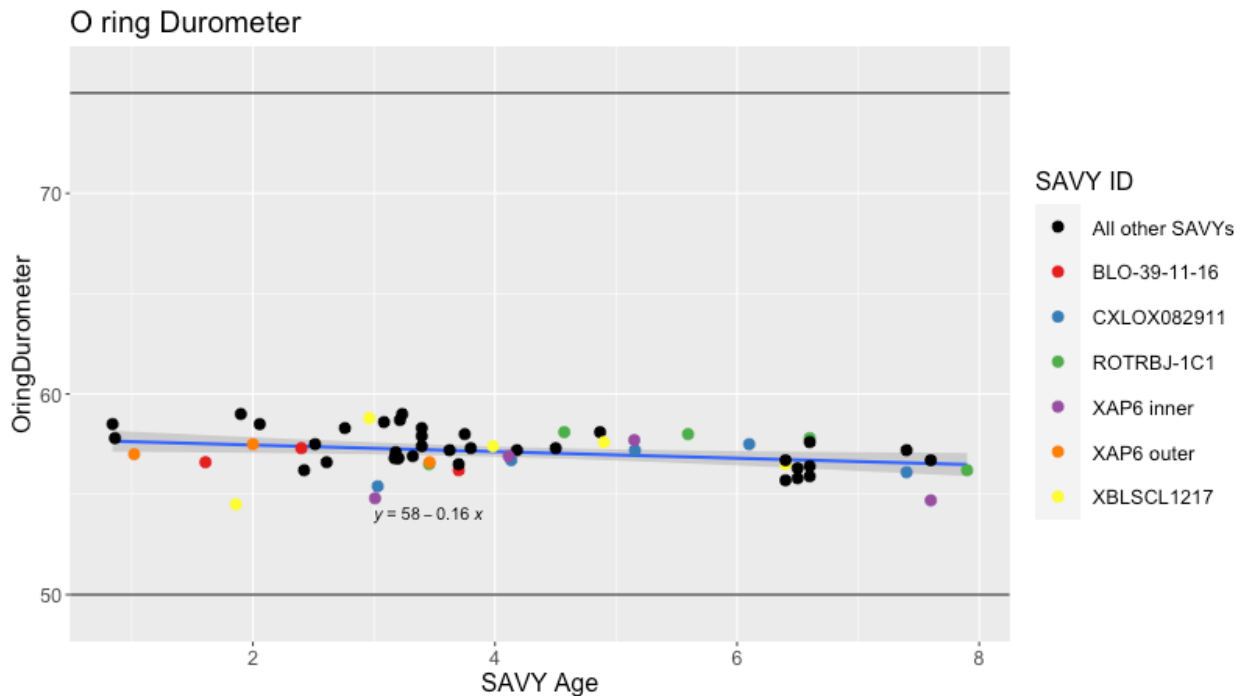


Figure 4-34 Durometer measurements versus SAVY age for containers from 2015-2020

Figure 4-35 shows compression set versus age. A compression set measurement is the amount of material that fails to return to its original size. Significantly increasing compression set values could indicate a degradation in sealing potential. Details of how the compression set data are collected and results for accelerated aging studies are provided in Weiss, et. al. 2016.

The surveillance compression set data were not collected in 2015 or 2016, there were three measurements in 2017. In 2018 three measurements were made but two of those were estimated based upon the average gland size for containers. In 2019 and 2020, compression set measurements were taken for all containers. The values ranged from 0.015 to 0.26. The maximum compression set value allowed is 0.65. All of the measurements are well below that value. Of the six containers with multiple measurements over time (multi-colored dots) only one has more than two measurements, BLO-39-11-16, which has three measurements. The compression set measurements indicate a small positive trend. However, looking at the items that have multiple

measurements there is not a positive increase except for XAP6 outer (orange dots). All other containers that have measurements over time are approximately the same value or slightly lower. Given the considerable variability in the measurements, more data are needed before a trend can be reliably assessed.

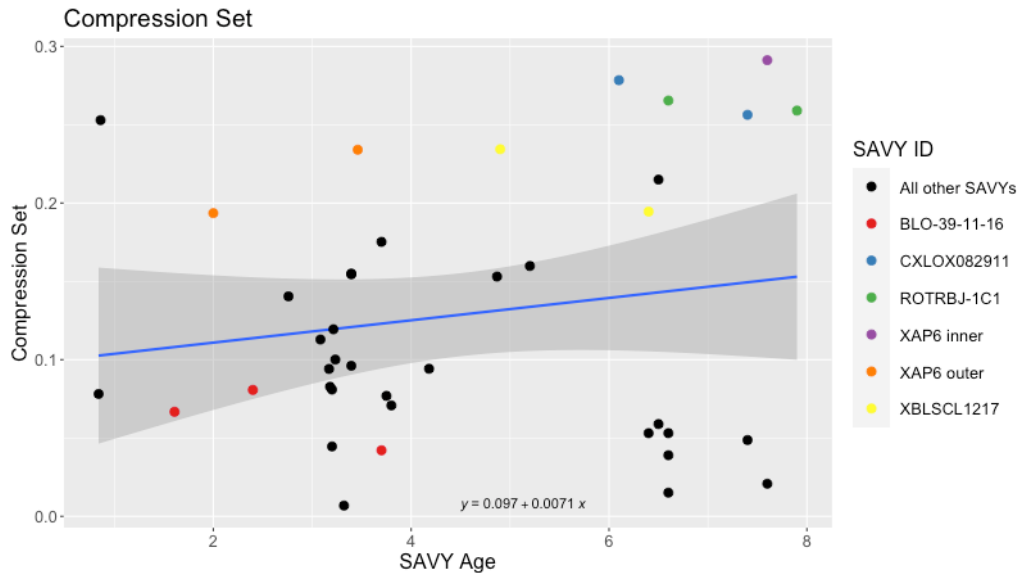


Figure 4-35 Compression set versus SAVY Age for SAVY containers in surveillance from 2015-2020.

4.3.3 Filter Discussion

Figure 4-36 shows particle penetration versus SAVY age. This measurement depends on how long the data are collected and the collection time can vary between measurements. The variability in the collection time results in variability between measurements leading to scatter in the actual measurement values across the years. The gray shaded area is the 95% uncertainty band for the trend line. Although the trend appears positive, the variability of the data is such that the trend is not statistically significant. Additionally, there is one point (highest black point) that causes the positive trend. This container was from one of the random items. It was the first SAVY-4000 to fail the particle penetration test and was found to have some damage on the filter membrane as indicated in Section 4.2.1.8. Removing this point, Figure 4-37 and Figure 4-38 show that there is a slight downward trend where all the containers are well below the acceptance limit of 0.03.

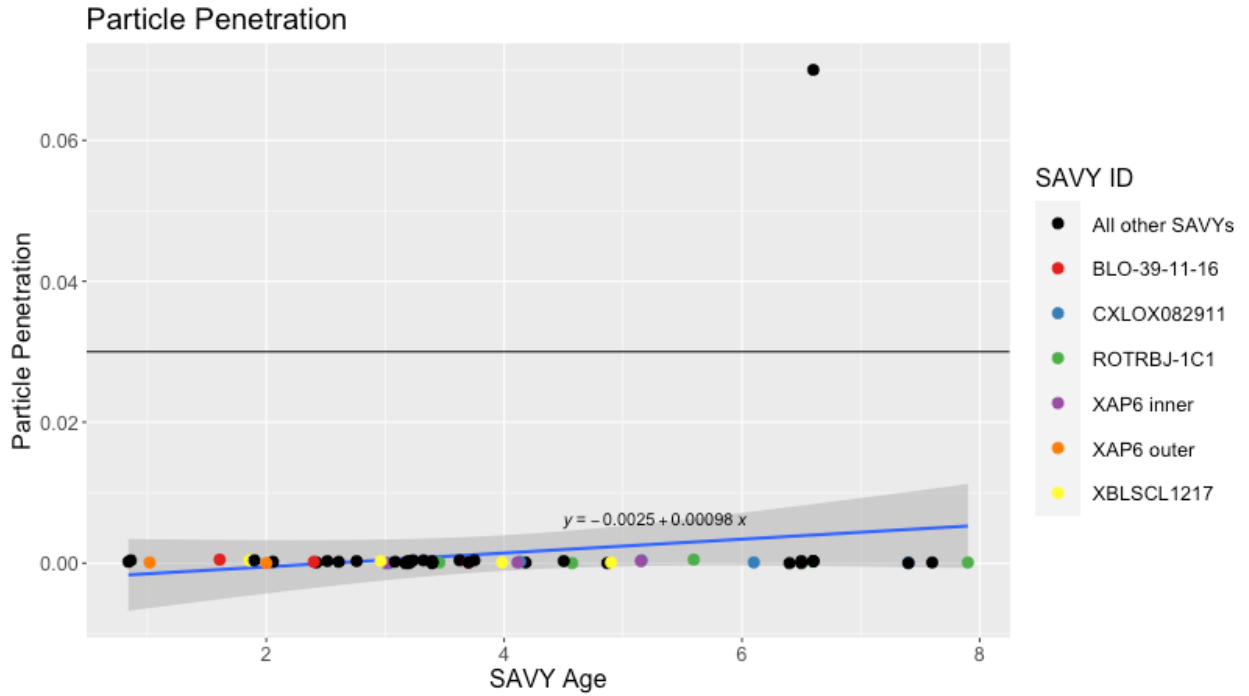


Figure 4-36 Trend analysis of particle penetration versus SAVY age for SAVY containers in surveillance from 2015-2020.

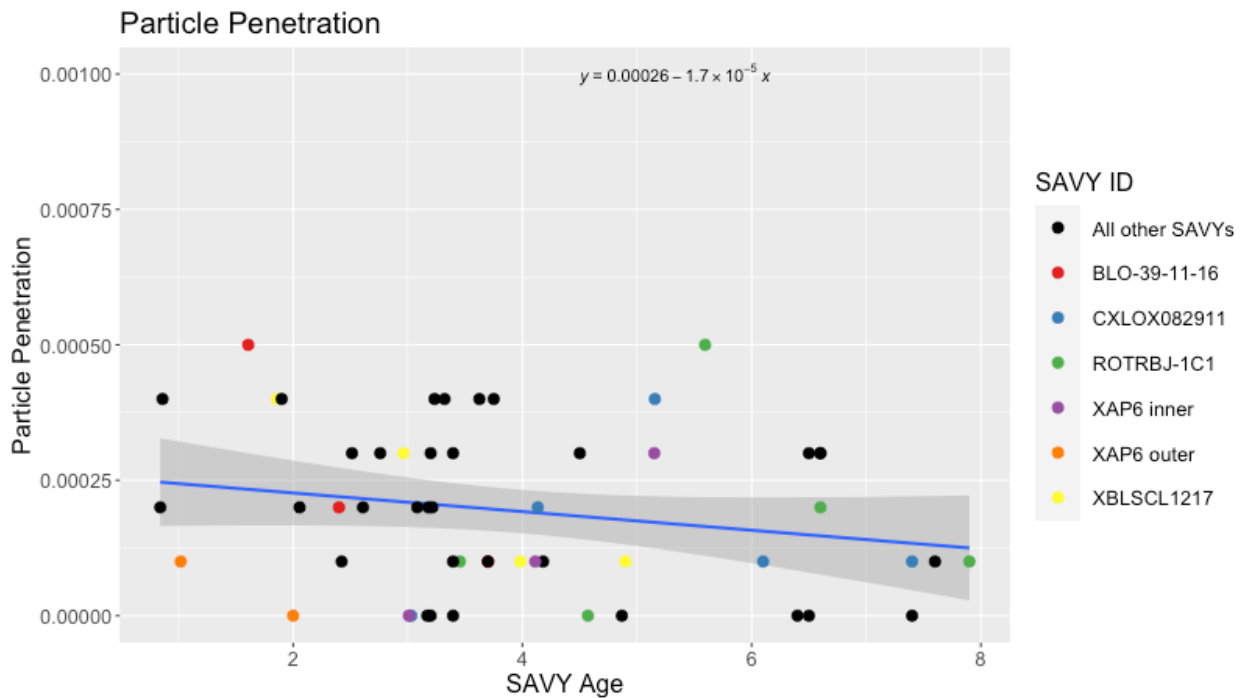


Figure 4-37 Trend analysis of particle penetration versus SAVY age for SAVY containers in surveillance from 2015-2020, outlier removed.

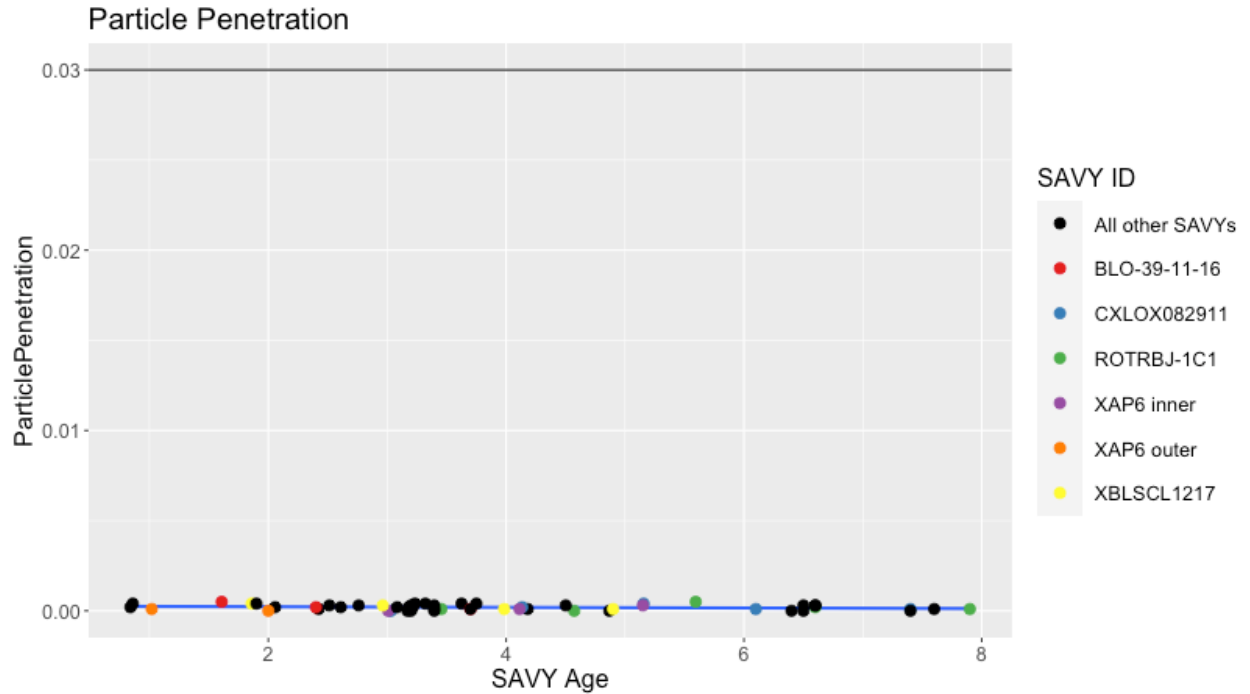


Figure 4-38 Trend analysis of particle penetration versus SAVY age for SAVY containers in surveillance from 2015-2020, outlier removed shown in context of acceptance limit.

Figure 4-39 shows the plot of filter pressure drop versus SAVY age. There is a negative trend in the data, however, there is a lot of scatter and the five containers measured multiple times (colored circles) show no change with age. To date, all filters have passed acceptance testing and a negative trend would not be an issue as the acceptance criterion does not include a lower limit.

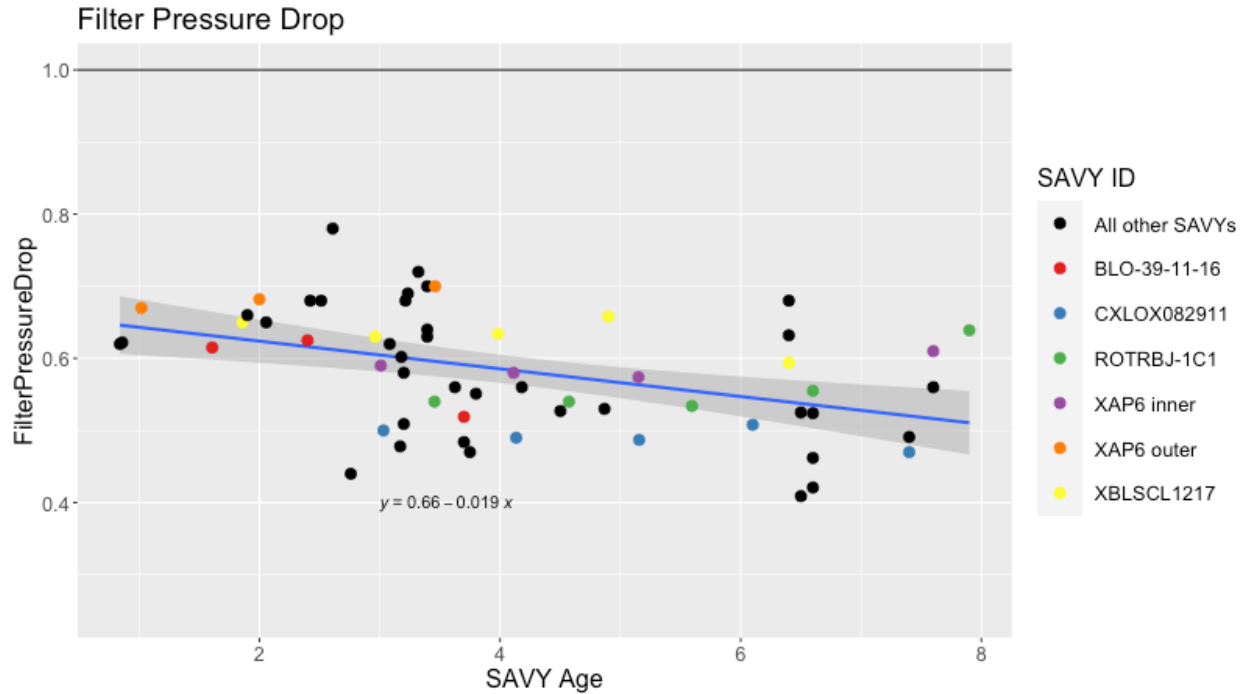


Figure 4-39 Filter pressure drop versus SAVY age for items in surveillance from 2015-2020.

4.3.4 SAVY-4000 Corrosion Discussion

The corrosion ranking scale was applied to all of the SAVY 4000 containers from 2015 to 2020. A total of 63 containers were ranked, with 6 containers that were in surveillance for multiple years. Of these, 41 were labeled as having no corrosion and 22 had some level of corrosion. Only one SAVY container was ranked in level 3, the highest level of corrosion, found in 2018 [5].

Both scatterplots and boxplots¹ are used to look at the impact of age, wattage and BDF on the corrosion levels, 0-“no corrosion”, 1-Isolated General Corrosion, 2- Light General Corrosion and 3- Heavy General Corrosion as described in Section 2.2.7. The scatterplot and boxplot of the corrosion ranking versus age (**Figure 4-40** and **Figure 4-41**) indicate that age alone does not have an impact on corrosion. Age varies across all the corrosion levels with the “no corrosion” category having the widest spread. Containers that were tracked over time, XBLSC1217 (yellow dots), XAP6 inner (purple dots) and ROTRBJ-1C1 (green dots) were not in the 2020 surveillance. These containers will be examined in a future surveillance.

¹ Boxplots are a way to show the distribution of the data. The interquartile range (IQR) is defined as the middle 50% of the data (from 25th quartile (Q1) to the 75th quartile (Q3)). This is the colored box. The median (Q2) is the black horizontal line in the box. The lines or whiskers emanating from the box are designed to identify potential outliers. The points beyond the whiskers look different than the rest of the data. The upper whisker will either be the maximum of the data or the first point that is less than $Q3 + 1.5 * IQR$. The lower whisker will either be the minimum of the data or the first point that is greater than $Q1 - 1.5 * IQR$.
https://en.wikipedia.org/wiki/Box_plot

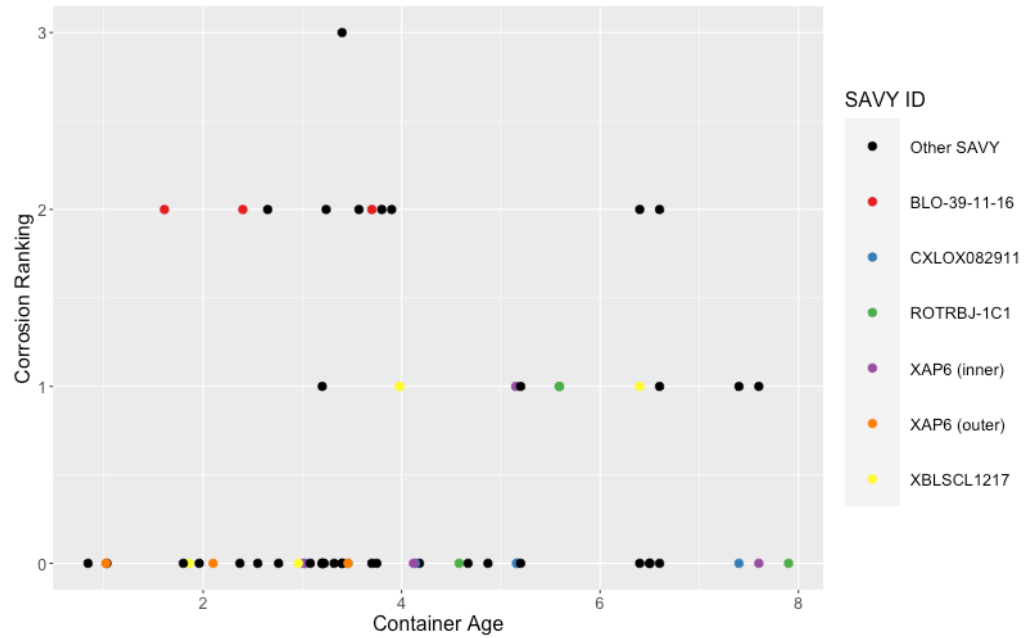


Figure 4-40 Scatterplot of SAVY 4000 container corrosion ranking vs. age from 2015-2020.

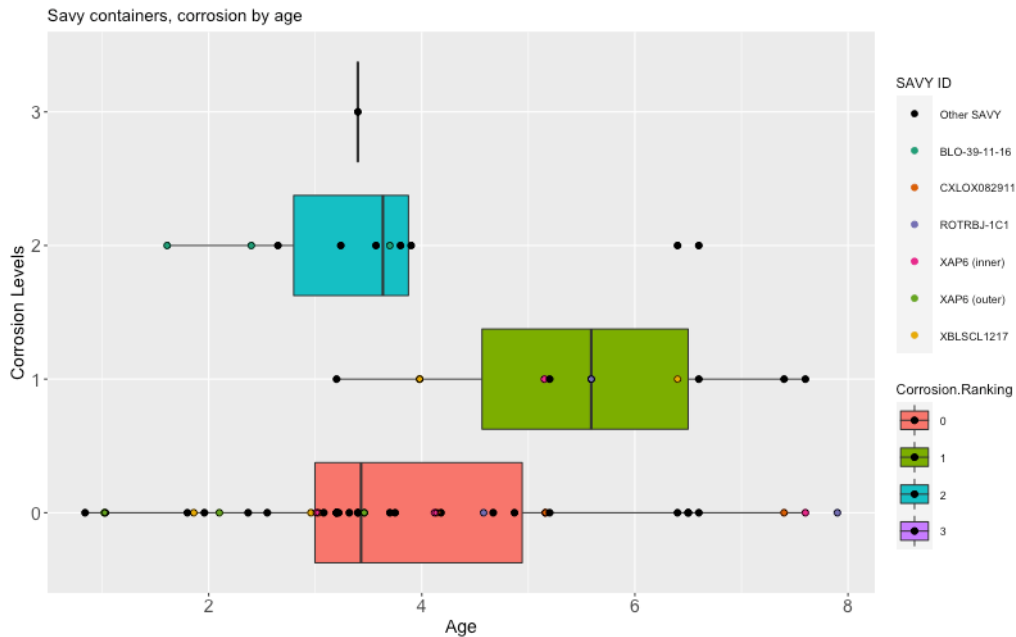


Figure 4-41 Boxplot of Corrosion rankings vs. age in years for the 2015-2020 SAVY containers.

Figure 4-42 and Figure 4-43 show corrosion ranking versus wattage. Currently, there is only one observation that had a corrosion ranking value of 3 which was in 2016, item AAP02OX. However, no other SAVY containers in surveillance have seen that high of

corrosion since 2016. In the 2020 surveillance there was one container, the stringer item, that had a high wattage but no corrosion. This item had five metals in it each with an individual wattage around 3.4, totaling a wattage of 16.9. The items that have been in surveillance multiple times, BLO-39-11-16, XBLSC1217, and XAP6 inner changed categories in 2018 but not in 2019 and were not examined in 2020. The initial BLO-39-11-16 corrosion was level 1 (covered in plot) and the initial XBLSC1217 corrosion was level 0. They will be evaluated in a future surveillance.

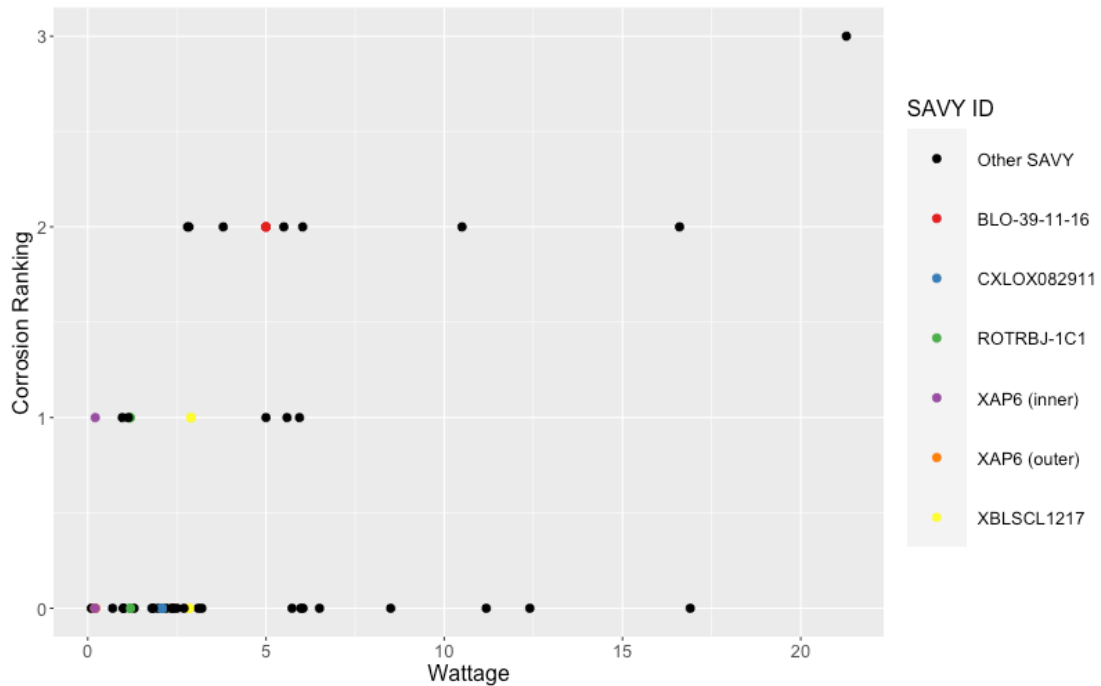


Figure 4-42 Scatterplot of SAVY 4000 container corrosion ranking vs. Wattage from 2015-2020.

The medians of wattage between the different corrosion categories shown in Figure 4-43 indicates a slight increasing median wattage for increasing corrosion rankings. There is a significant difference between the no corrosion category and category 2.

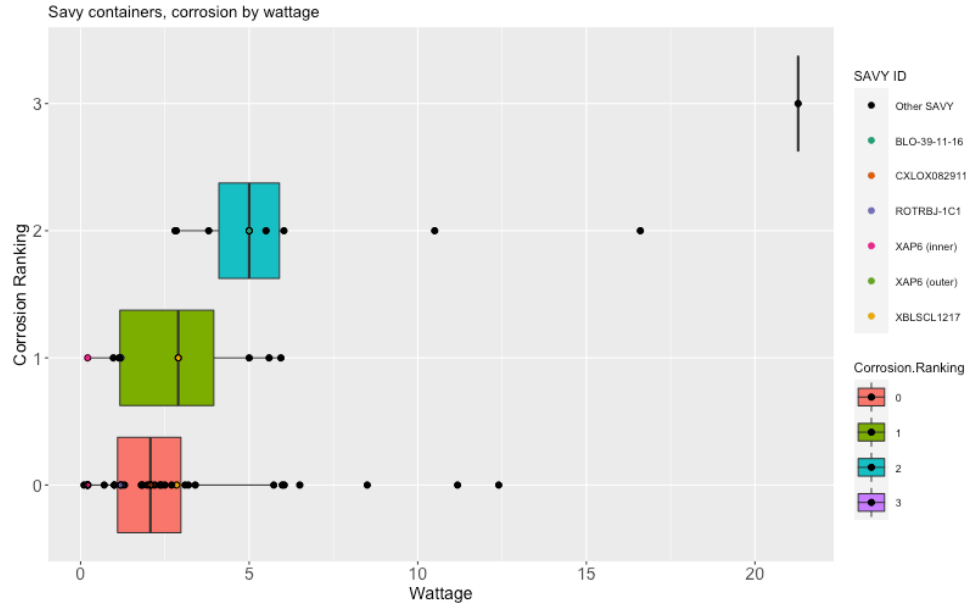


Figure 4-43 Boxplot of Corrosion rankings vs. wattage in years for the 2015-2020 SAVY containers.

The bag degradation factor (BDF) combines age, wattage and container size into a single value [10]. BDF is defined as age times wattage divided by the square of the radius of the container ($BDF = a \cdot w / r^2$). BDF captures a possible interaction between the three factors. The plot of corrosion ranking versus BDF (Figure 4-44) shows that of the eight containers with BDF greater than 2, six of them have corrosion. (The stringer item was not included in the BDF analysis as it did not have a bag-out bag, which is considered the root cause of corrosion.) The boxplots (Figure 4-45) indicate increasing median values as corrosion level increases, but the differences are not statistically significant.

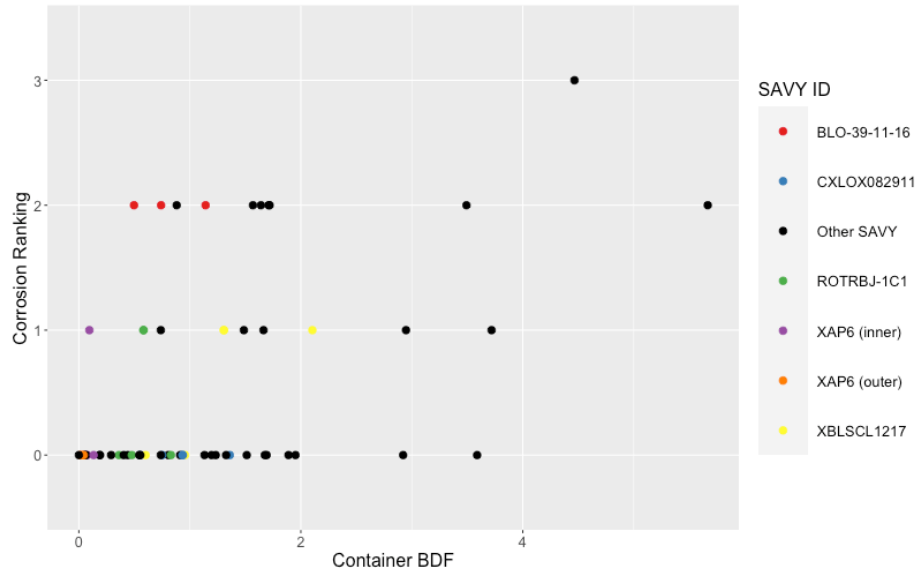


Figure 4-44 Scatterplot of SAVY 4000 container corrosion ranking vs. BDF from 2015-2020.

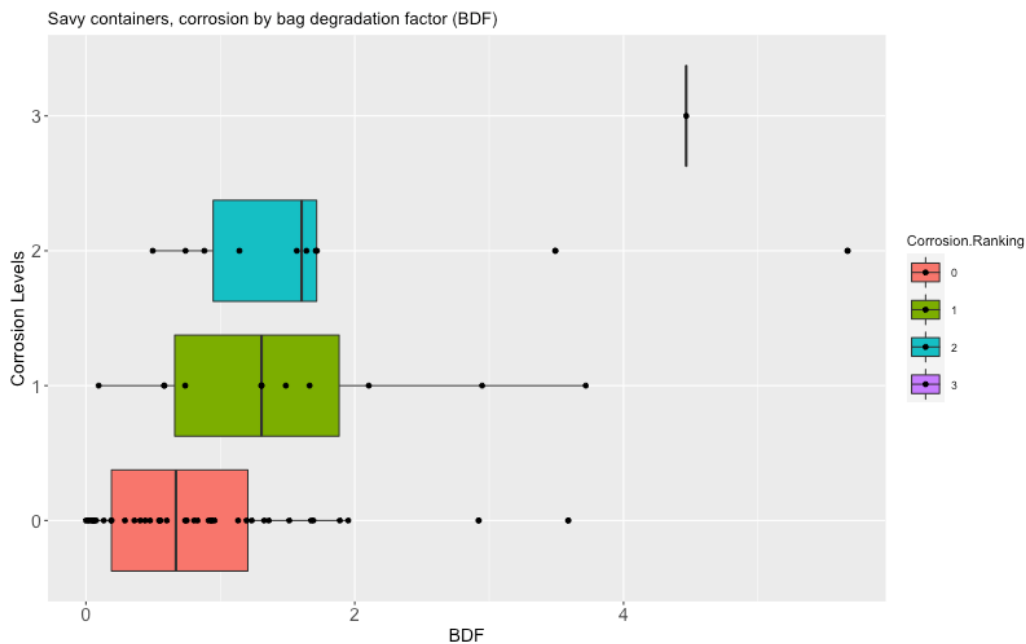


Figure 4-45 Boxplot of Corrosion rankings vs. BDF in years for the 2015-2020 SAVY containers.

4.3.5 Hagan Corrosion Discussion

The corrosion ranking scale was applied to all the Hagan containers from 2013 to 2020. A total of 38 containers were inspected based upon visual analysis. Of the 38 containers ranked, 13 were labeled as having no corrosion and 25 had some level of corrosion, with eight Hagan containers labeled in category 3, the highest level of corrosion [5]. Of the

three containers observed in 2020, there was only one Hagan that had corrosion observed, it was a level 1 the lowest level of corrosion.

Figure 4-46 and Figure 4-47 show scatterplots of the corrosion ranking versus age and boxplots of ages per corrosion ranking, respectively. Similar to the SAVY, there is a lot of variability in age, especially for the non-corroded containers. These plots indicate that age alone does not predict corrosion.

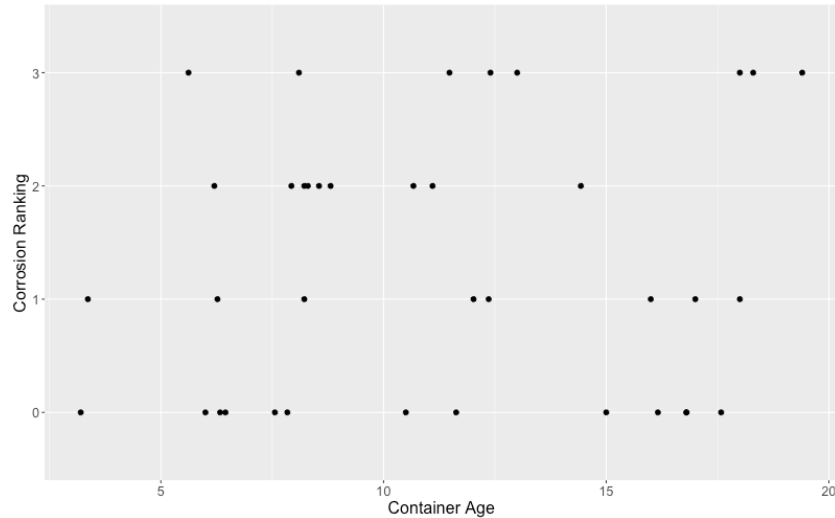


Figure 4-46 Hagan container age vs. corrosion ranking for data from 2015-2020.

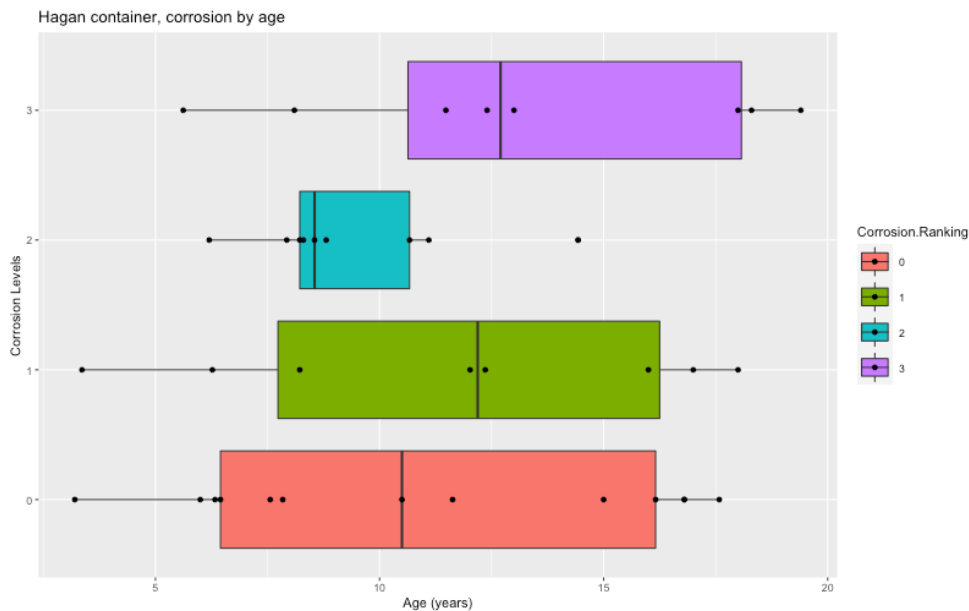


Figure 4-47 Boxplot of Hagan corrosion ranking vs. container age for data from 2015-2020.

Figure 4-48 and Figure 4-49 show plots of the corrosion ranking versus wattage and boxplots of wattage per corrosion ranking, respectively. The scatterplot in Figure 4-48 shows that all containers have some corrosion for wattages greater than 10 watts. The boxplot shows that there is a general increasing trend of wattage medians as corrosion levels increase. However, there is not a significant difference between the medians. There is considerable variability in wattage for those containers having corrosion.

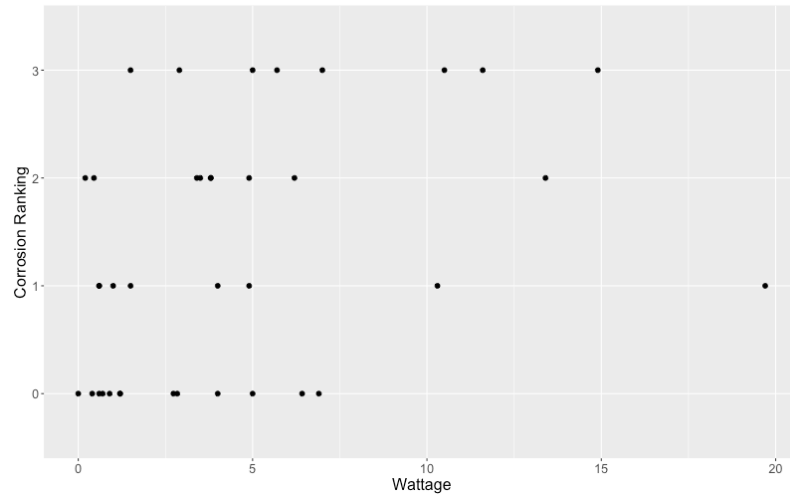


Figure 4-48 Scatterplot of Hagan container wattage vs. corrosion ranking for data from 2015-2020.

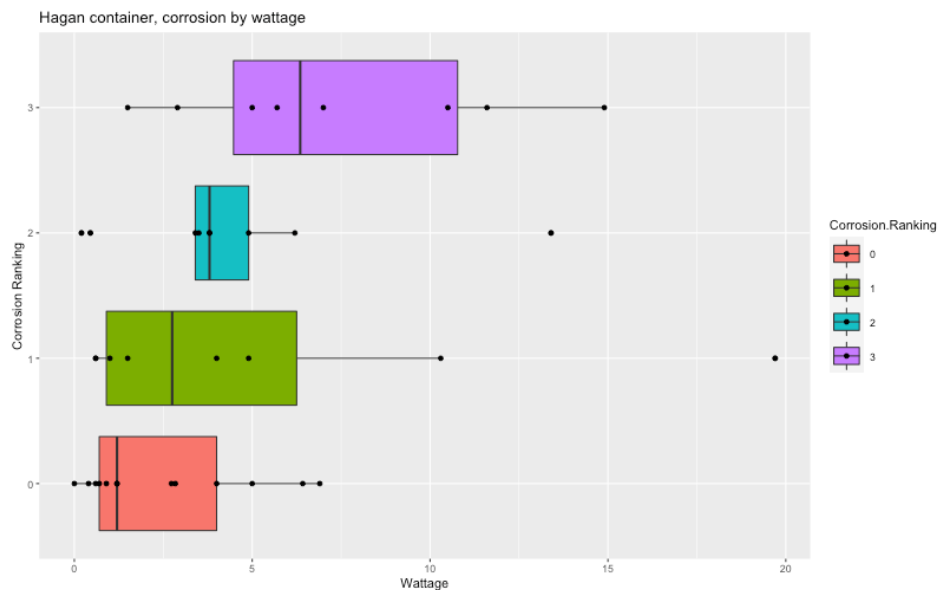
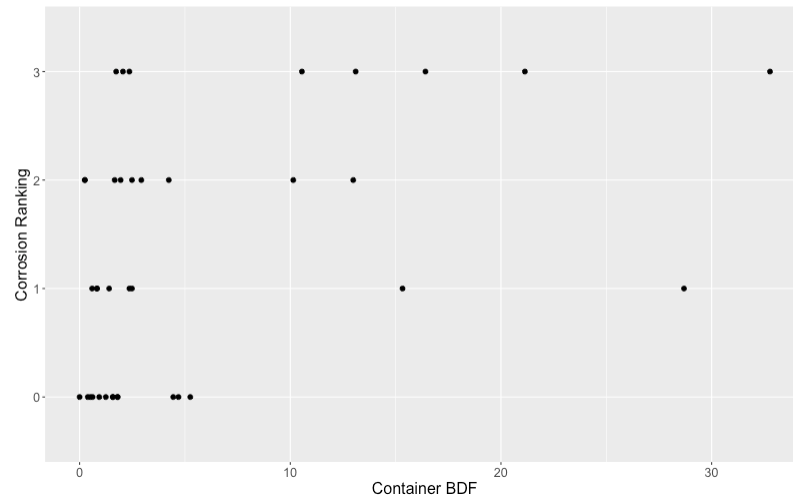


Figure 4-49 Boxplot of corrosion ranking vs. wattage for data from 2015-2020.

The plot of corrosion ranking versus BDF, Figure 4-50, shows that all nine containers with BDF greater than 10 have some corrosion. The boxplots of corrosion ranking versus BDF (Figure 4-51) show a slight increasing trend of BDF medians, i.e., the greater the BDF median the higher the corrosion ranking. Again, similar to wattage the general trend of higher medians is not significant.



4.3.6 Conclusion

The trending evaluations of He leak rate, particle penetration, filter pressure drop, durometer (Shore M hardness) and compression set (CS) for the SAVY containers show no important trends over time, indicating that the O-rings and filters have not degraded.

The corrosion analysis for the SAVY 4000 and the Hagans indicate that high wattage and/or high BDF could result in an increased probability of having corrosion. There is considerable variability in the data and the limited number of observations (given the variability) is not sufficient for determining statistically significant results. However, with this limited data high BDF does better than wattage alone, indicating a possible interaction between wattage, age and container size. Nevertheless, containers with relatively low wattage and low BDF have corrosion levels 2 and 3. This finding indicates that additional factors may be important to understand and predict corrosion. For example, environmental factors such as relative humidity, which has been shown to be an important factor for corrosion, should be considered in future analyses, if possible.

5 Summary and Conclusions

A total of 16 storage containers 13 SAVYs and 3 Hagans were processed under the FY20 SAVY surveillance plan; this includes 1 Hagan IoOP. 14 containers, 2 Hagans and 12 SAVYs underwent the complete set of visual inspections, functional checks and qualitative performance testing which includes helium leak, filter efficiency, water penetration, durometer and compression set measurements. 13 of those tested passed the criteria, with the exception of the first SAVY failure in both filter efficiency and water penetrations testing. Both the remaining two containers, one SAVY and one Hagan were introduced due to internal contamination concerns. With some extended evaluation capability within the glovebox, leak test and compression set data were collected on the introduced SAVY, passing both those criteria.

This year surveillance activities continued to reveal some corrosion inside of the storage containers. Minor corrosion was found on 4 SAVY containers and 1 Hagan with a corrosion ranking of one, the one SAVY had more significant corrosion with a ranking of two. Once Hagans are processed they are removed from surveillance, ten of the thirteen SAVY 4000 containers that were found to have minor to no corrosion on the inner surfaces were returned to service and will have the option to be surveilled going forward. The SAVY with a corrosion ranking of two was not significant enough to deem further evaluation and would have been returned to service had it not been dropped on its way to perform surveillance evaluations. The fact that contamination has not been found on any of the container external surfaces indicates that the containers are performing their primary function of maintaining their contamination barrier and protecting the workers that use these containers on a daily bases.

A significant finding in FY19 was that 2 like items that were surveilled exhibited different levels of corrosion. The differences in these items leads the container subject matter experts (SMEs) to believe there are other conditions that have not been identified that may be contributing in the discrepancy of results. The SMEs have hypothesized that

position relative to other items in their storage location may be a cause of the differences. However, the items were in opposite sides of the same room.

A number of chemical subform “dioxide” MT52 were processed this year which constitutes a subset of containers packaged with similar characteristics; with little to know sign of corrosion up to 6 watts. As dioxide the primary driver in corrosion would be reaching a thermal load that then drives bag degradation for HCl vapor formation. Add to this number all dioxide items processed sense 2015 Hagan or SAVY it is evident items above 3 watts can have significant corrosion but there are at least as many that show no sign of corrosion at elevated wattage as have corrosion. This may point to the need for understanding in greater detail other parameters that may be at work that cause corrosion in one case and not in another. One of these is the well know understanding that RH plays a key role in driving the corrosion reaction. Differences in RH may help explain why two similar items exhibiting degradation in the bag out bag, have resulted in one in a corroded condition and the other remains pristine. A better understanding of such key environmental conditions may be an enhancement in surveillance worth considering.

Surveillance in FY21 will continue to target containers with a high likelihood for corrosion. These containers include other containers with MSE salts with a high wattage to volume ratio or bag degradation factor [10]. Additionally, the future surveillance will target other material forms and material types not yet included in the surveillance program to investigate corrosion in these containers.

6 Recommendations

6.1 In-glovebox Capabilities

In FY20 the ability to evaluate container performance inside of gloveboxes was demonstrated with the processing of the one SAVY that was introduced; capturing both O-ring thickness and helium leak test data. Due to the number of containers being introduced, this in-glovebox capability is a valuable improvement to the surveillance activities by allowing data to be gathered that would otherwise be lost and will be maintained in future surveillance. The intent is to add water ingress testing as an additional in-glovebox capability in future efforts.

6.2 Material Types and Forms

The FY21 surveillance plan should continue to focus engineering judgment (EJ) sampling on the 12 IDC groups identified as worst case materials. In particular, EJ sampling should target a Hagan packaged with MSE salt similar to 18H7, which had a large dose in a small volume container. The condition of this container was the worst seen to date in surveillance. However, in order to ensure that the surveillance program bounds the inventory of stored material, it is still recommended that the surveillance program includes other nuclear material types and material forms in the storage population that could be comparable to plutonium. For example, neptunium (MT 82) and uranium-233 materials have not yet been sampled in surveillance and should be prioritized by factors such a dose and the potential for corrosion.

A significant opportunity is being presented to surveil several SAVY containers that contain items with high Am. These items are scheduled to be shipped off sight so it is recommended that the containers are surveilled as they are being repacked.

6.3 Random Sampling

In addition to EJ sampling, in FY20 a random sample of SAVY containers over five years of age was added to the surveillance program. The random sampling provides confidence that an unexpected degradation, failure or usage mode for the SAVY containers will be identified. This has proven out with one of the six SAVY random samples processed this year having identified a failure with the filter component. The approach of combining EJ and random sampling has been used in other container safety programs (e.g., the 3013 program) and is considered to be a cost-effective approach for ensuring the long-term integrity of storage containers packaged with nuclear materials. This random sampling approach will reduce the opportunity for annual surveillance, but based on the trends seen with the past annual surveillance items it will be more beneficial to let a few years lapse before those containers are surveilled again. Random sampling will continue in the out-years.

6.4 Like Item Comparison

Due to the fact that 2 containers with nearly identical items in them, or even containers with rather similar items in them, have been found with significantly different amounts of corrosion, it might be worthwhile to select some surveillance items that have like items in them and packaged with similar characteristics or establish an awareness of how characteristics may differ. This could be used to identify the parameters for corrosion, such as variations in RH, in storage containers.

6.5 Alternative Bag-out Bag Surveillance Item

In order to assess the real world performance of the alternative bag-out bag material (Aromatic Polyurethane), a pilot program involving bagging out six challenging contents with APU ether bags will be initiated in FY21 to observe their performance over time. This effort is dependent on the ability to obtain bag out bags made of APU ether. Results from these items under surveillance will help to confirm other experimental results that suggest that removing PVC bags eliminate the primary cause of corrosion in the containers..

6.6 Photo Capability and establishment of hold points for Surveillance

It has recently been recognized that a capability to capture photos in the lab that surveillance takes place would greatly improve the effectiveness of evaluating the growth of corrosion in containers that are being surveilled on a regular basis. By capturing photos in the lab it would be possible to control the lighting so that the color of the photos remains consistent from year-to-year allowing a more comprehensive analysis to be completed on the photos that are captured. A camera has been made available that allows

the container surveillance team to gather photos of every container that passes through the program.

Operators are required to report suspected or identified packaging issues per the contingencies (5.3) section TA55-DOP-091, TA-55 Nuclear Material Packaging. In addition to the reporting requirements stated in the current version of the operating procedure, the Container Safety and Engineering team requests notification (contmgmt@lanl.gov) when any of the following list of hold points are observed:

- Contamination detected on Outer Container (inner or outer surfaces)
- Corrosion outside of sealing surface (e.g. on threads, outside of filter, on TID wire)
- Corrosion covering >95% of inside surface (little to no bare metal visible)
- White powder outside of sealing surface (e.g. near filter)
- O-ring missing
- O-ring crimped or damaged
- Bulging or paneling
- Dents > 1 inch in diameter
- SAVY filter with visible hole(s)

A more focused effort in this way will help manage effective data capture in both formal surveillance and IoOP or just find issues as items are handled from the general population.

6.7 Further work on implementation of MINTS

The Modular Non-destructive Test System (MINTS) is a test table design that provides a strong technical, financial, and environmental solution for analyzing plastic deformation and corrosion of nuclear material storage containers[12]. The project has resulted in a test setup that can interrogate nuclear material storage containers non-destructively, rapidly, real-time, and in-situ. The test setup includes three techniques that can be used to obtain a variety of container health information. The system combines ultrasonic, eddy current and laser detectors on a single platform. This approach represents a paradigm shift in how nuclear material storage containers are assessed for structural health. The equipment and test methodology is expected to be deployed as part of the container surveillance program.

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